PRINTED ON THIN PAPER FOR FOREIGN CIRCULATION

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C. 2

VOL. CVIII.—No. 2796.] *LONDON: FRIDAY, AUGUST 1, 1919.* [*Registered at the General Post Office as a Newspaper.*] PRICE...9d. BY FOREIGN POST...1s. 2½d.

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(3) Teacher of Workshop Practice (Metal).
(A knowledge of Patternmaking will be a recommendation.)

Salary according to County scale for Secondary Schools, commencing £170–£220 per annum, according to qualifications and experience.

Application forms, which must be returned not later than August 8th, may be obtained from R. DEMPSHY, 1, Selborne Road, Walthamstow. X 482

SUNDERLAND EDUCATION COMMITTEE.

JUNIOR TECHNICAL SCHOOL.

Applications are Invited from persons with scientific or technical qualifications for the POSITION of HEADMASTER of a Junior Technical School to be opened in October next.

The aim of the School is to give a three years' course of pre-apprenticeship training to boys from 13 to 18 years of age. Applicants should possess a University Degree, or its equivalent, and have had teaching and some administrative experience. The nature of any experience in engineering workshops or drawing offices should also be stated.

Applications, accompanied by three recent testimonials and three references, must reach the undersigned (from whom further particulars and forms of application can be obtained) by Monday, August 11th.

Salary:—£400 to £450 by annual increments of £10. Canvassing will be a disqualification.

HERBERT REED,
Chief Education Officer.

Education Offices,
15, John Street,
Sunderland.
July 10th, 1919. X 228

THE TECHNICAL COLLEGE, LOUGHBOROUGH.

H. SCHOFIELD, M.B.E., B.Sc. (Hons.), London, A.R.C.Sc., London, Principal.

The Governors of the College propose to make the following

Appointments for the commencement of the Autumn Term:—

(1) A LECTURER IN MECHANICAL ENGINEERING.

(2) A LECTURER IN ELECTRICAL ENGINEERING.

Applicants should possess a University Degree or its equivalent, and should have had practical experience in recognised engineering works. Salary £300 per annum, rising by increments of £25 per annum to £350, further increments being considered subject to satisfactory service.

(3) LECTURER IN MATHEMATICS.

Applicants should possess a University Degree with Honours in Mathematics, or its equivalent. Salary £300 per annum, rising by increments of £25 per annum to £350 per annum, further increments being considered subject to satisfactory service.

(4) LECTURER IN ECONOMICS AND COMMERCE.

Applicants should possess a University Degree in Commerce, and practical business experience is desirable. Salary £350 per annum, rising by annual increments of £25 per annum to £450.

(5) LECTURER IN FRENCH AND GERMAN CORRESPONDENCE.

Applicants should have had actual business experience as Foreign Correspondents, preferably with an engineering firm. Salary £300 per annum, rising by £25 per annum, to £350, further increments being considered subject to satisfactory service.

Applications, with not less than three recent testimonials, should be submitted before August 27th to the PRINCIPAL, from whom forms of application and any further particulars may be obtained.

W. A. BROCKINGTON, O.B.E., M.A.,
Director of Education. X 531

THE WORKS AND PRODUCTS OF MESSRS. BARR AND STROUD, LIMITED.

It was in 1888 that Professors Barr and Stroud, at that time associated on the staff of the Yorkshire College, Leeds, began experimental work with the range-finder which bears their names. Dr. Barr occupied the Chair of Engineering and Dr. Stroud that of Physics, and much common interest existed between them in connection with the discussion and study of scientific problems. Both had given evidence of inventive ability. It is interesting to us to know that it was an advertisement which appeared in ENGINEERING in the early part of 1888 which turned the attention of the professors to the subject of range-finders. The advertisement was issued by the War Office and called for proposals from persons desirous of submitting Infantry range-finders for competitive trial. Professor Barr, seeing this advertisement, suggested to Professor Stroud that they should design an instrument to meet the specified conditions, and should submit it for trial. This proposal was carried out and the main features of the instrument were thought out in a few weeks. It should be said that at that time neither of the inventors were familiar with earlier range-finders, and that they approached the problem as new. Their instrument was thus in every way an original one, and it is a remarkable tribute to its designers to be able to say that its main features have remained unchanged up to to-day.

The first range-finder constructed by Messrs. Barr and Sroud was made in 1888-1889, and was tested at Aldershot in competition with others of various forms. It was of the single-observer type, with which the inventors' names have since been so closely associated, but the competition was not confined to instruments of this class. The results obtained were promising, and a second instrument was made with a view to further trials. The second series of trials, however, led to disappointment, mainly in consequence of certain optical details of the instrument having been altered with a view to cheapness of production. As a consequence, the range-finder was not accepted by the Army, and the Watkins Mekometer two-observer instrument was retained as the standard Infantry range-finder for many years. Even at the outbreak of war in 1914, the Barr and Stroud rangefinder had been adopted to but a very small extent by the British Army, although it had then been supplied in very large numbers to various of the Continental Powers. August, 1914, however, quickly bred a difference in this state of affairs, and during 1915 and 1916 the firm were supplying more instruments per week to the Army than the total number supplied to it before the war.

Returning to our chronological survey, it is to be recorded that the lack of success of the early Barr and Stroud instrument in the Army trials was more than retrieved by the results of trials in the Navy. In 1891 the Admiralty advertised publicly for proposals in connection with Naval rangefinders, and also directly asked Dr. Barr and Dr. Stroud to submit an instrument. By this time Dr. Barr had been appointed to the Chair of Engineering in Glasgow University, but his association with Dr. Stroud was unbroken. An instrument was accordingly designed to meet the Admiralty requirements, and was constructed under Dr. Barr's personal supervision. The mechanical parts were made in the workshop of Mr. James White of Cambridge-street, Glasgow, and the optical parts by Mr. Adam Hilger of London. The instrument was tried at Chatham on H.M.S. Arethusa, in April, 1892, and its accuracy more than satisfied the specified requirements. As a result of this the Admiralty, in 1895, ordered five range-finders of an improved type. The first of these was the first Barr and Stroud range-finder to be actually sold. Again, the mechanical parts were made in the workshops of Messrs. James White, Limited, under the inventors' supervision. The assembling of the optical parts and the adjusting were carried out in an upper room of Dr. Barr's house.

The Admiralty order for five instruments was followed by a considerable demand for range-finders and a workshop was obtained for adjusting and finishing the instruments, and to serve as a central office, in a building being erected by the Glasgow District Subway, in Byres-road. In two years a further works had to be taken, and by 1903 quite a number of small premises were occupied in the neighbourhood of the Byres-road workshop. In 1904, the work in sight justified the erection of a special building in which the whole of the processes of manufacture could be organised under one roof. Ground was accordingly acquired at Anniesland on the west side of Glasgow, and a three-bay single-storey building, 60 ft. wide and 150 ft. long was erected. This now forms part of the main machine shop. Before this initial building was completed, it was found that it would be too small and an office building three-storeys high, and of 60-ft. frontage, was added. A brass foundry was built later, and the first casting was made in 1905. From this time onwards extensions have been almost constantly in progress. We described the factory in its original form in 1906,* but, in view of the enormous extension which has taken place since then, we now propose to deal with it anew.

Before proceeding to a description of the actual factory, we should say that the firm of Barr and Stroud was formally constituted in 1903, when a partnership was entered into by Dr. Barr, Dr. Stroud and Mr. Harold D. Jackson. This latter gentleman had joined the inventors as an assistant in 1892. In 1913 a limited company was formed, and Mr. James W. French and Mr. N. J. Maclean were assumed as co-directors. Before the war a very large business had grown up and the company had established branch factories in France, Austria and Hungary. The reputation of the Barr and Stroud range-finder had become world-wide, and Germany was the only great naval power whose warships were not equipped with Barr and Stroud instruments, while they had been supplied in large numbers to the French Field Artillery, Cavalry and Infantry. In addition to range-finders, Messrs. Barr and Stroud have for a number of years manufactured fire-control gear and other allied material, but rangefinders have always been the main and most important part of their business.

The factory with which we are concerned, considered as a physical entity, contains much of very great interest, but we are not sure if the methods of management employed within it are not of even greater interest. As bearing on this aspect of the matter, we would like to quote some paragraphs from a description of Messrs. Barr and Stroud's works, which we wrote in 1914. That description, owing to the incidence of the war, was never published. At that time we wrote as follows:—

"In describing the works, it will be well to deal with each shop more or less independently, following through, as far as possible, the manufacture of the instruments from the foundry and material stores to the packing-shop. Before doing this, however, there are certain features, common to the whole factory, to which we would like to refer. These features are concerned in the main with the firm's treatment of its workpeople, and one aspect of them would be obvious to the most casual visitor to the works, who could not fail to note the unusually smart appearance of the shops. One is fairly used nowadays to examples of the considerate treatment of workpeople by the provision of adequate arrangements for their convenience, but it would not be easy to find a case in which such provision appears to have led to such good results. We do not imagine, however, that it is merely owing to the fitting of proper lockers, wash-basins, &c., that Messrs. Barr and Stroud's shops present such a smart appearance. It is partly due to excellent lighting and partly to the fact that they are kept clean, and that articles not in use are not permitted to be left lying about. The effect is also greatly helped by the fact that all workmen wear overall coats of similar colour and type. The shop floors are kept clean by being swept by the labourer's gang during the mid-day meal interval, during which none of the other workpeople are allowed inside.

There are other regulations which lead to the aspect of good order and tidiness in the shops. For instance, each employee is required to provide himself with a clean apron or set of overalls at least once a week. Such aprons or overalls may be purchased from the firm at cost price, and if in good condition, are bought back from the men, if they leave, at half the original price. Again, spitting on the floor or on any other part of the shops is forbidden. For those who require them, spittoons are provided. This, we think, is a most unusual, but at the same time, a most salutary regulation. Further, no meals are allowed to be eaten in the shops, and, as we have already said, the workpeople must leave the shops during the meal intervals unless, of course, they are detained by special work. This is no hardship, since proper dining-rooms are provided for employees who wish to take their meals at the works. Order is further maintained by a regulation that no subscription lists are allowed to be passed round the shops during working hours, except such as have been approved by the Shop Committee, to which we will refer later.

After mentioning these various regulations, we must hasten to say that it would by no means give a true impression of Messrs. Barr and Stroud's works if we were to let it be assumed that an appearance of tidiness and smartness has been attained merely by the imposition of a series of cast-iron rules. Rules are easy to make, but then carrying out to any useful purpose requires something more than a legislative trait. It would be impossible to spend any time in the shop without realising that although they may be ruled with all necessary strictness, there is through all an underlying understanding with, and consideration for, the workpeople which is far from common. This sort of thing is in the atmosphere, and is difficult to define, but there are many concrete evidences of it in the shop procedure. As quite a minor matter, but a very illustrative one, we may mention that for two periods each of 20 minutes during working hours—one in the morning and one in the afternoon—smoking is permitted in the shops. Like most wise concessions, this arrangement is by no means one sided. It is a relief and gratification to many of the employees; while, from the firm's point of view, it not only improves the workpeople's efficiency by improving their content, but quite remarkably diminishes the load factor of the lavatories."

The above, as we have said, was written in 1914. Revisiting the shops in 1919, we have no wish to withdraw any of our earlier remarks and judgments. None the less, the storm of war has passed in the five intervening years, and has left its mark on the Barr and Stroud factory as on all other things. Before the war, the firm had 1,012 employees. During the war, the figure rose to 2,400. In July, 1914, the wages bill was 1,644*l.* a week. This rose to 6,500*l.* a week. In the five years which passed between our two visits, the workshop area increased from 96,000 sq. ft. to over 200,000 sq. ft. These are material things, but they have their reflex in the immaterial. The careful judgment and wise consideration which have built up the business of Messrs. Barr and Stroud, and which have meant so much for the true welfare of their employees, have, we fear, found themselves faced with a task enormously intensified by the conditions engendered by the war. A common *esprit de corps* and a good understanding between employer and employed is a thing which takes time to build up. It cannot be bought ready made. In time, happily, it may, in a factory, become a tradition. New employees are gradually absorbed into it. A sufficient jar may, however, upset it, and we fear the great and rapid increase in the size of Messrs. Barr and Stroud's business, which was forced by external conditions, and in addition the necessary but inflexible "control" regulations of the Government, made it difficult to retain the old atmosphere which it was such a pleasure to breathe in 1914.

We are not suggesting that at any time Messrs. Barr and Stroud's has ceased to be a model factory. It has not. All we are really attempting is to suggest the difficulties which war time brought to the management. Throughout, in as far as we are able to judge, there was no lowering of ideals and none of the subtle cords uniting the workpeople with the management were severed. At times, perhaps, they neared the elastic limit, but they

* See ENGINEERING, vol. lxxxi, pages 579, 678, 749 and 811.

stood, and in the new age into which we have lived, one can have no doubt but that these cords are destined to form no mean item in a new and perhaps even better tradition which one may hope will grow up in the industrial world. For those who would wish to build up a factory routine on business lines, and yet with a clear-eyed knowledge of, and sympathy with, the very human units which must make up the workpeople, we suggest the factory at Anniesland as an example and a pattern.

Having said perhaps more than enough in general terms, we may now consider some of the actual and detailed methods in vogue at Messrs. Barr and Stroud's works. As first in order of importance, we may place the shop system. Although this has no immediate and obvious connection with the subject we have just been dealing with, indirectly it must influence the well-being of every employee in the factory. A premium system of payment is in operation, the amount of premium paid bearing the same relation to the time rate of wages that the time saved bears to the time allowed. This premium system necessarily influences the works organization and involves a rate fixing, or, as in this case it is called, a Planning Department. The function of this department is to originate premium cards and instruction sheets for each operation performed in the shop. The instruction sheets detail the method of machining to be employed for every operation and any necessary special tools are ordered by the Planning Department. This department has nothing to do with design and works to drawings and limits supplied by the drawing office.

The premium cards and instruction sheets prepared by the Planning Department are distributed to the shops by the Production Department. This department has a controller in each shop, whose duty it is to issue the cards to his shop in the order of importance, or urgency, of the job they refer to, and in proper reference to the machines which are available for new work. The controller has also to arrange for the bringing forward of material or special tools which may be required in connection with the cards he issues. The controller is not the shop foreman, and has nothing to do with the workpeople. All instructions to workpeople relating either to work or discipline come only through the foreman, and it is definitely laid down that the foreman is the executive officer in his own department, and is the only man who can give an order to a worker. The Drawing Office, the Planning Department, the Production Department and the shop foremen have each no authority over the others, and disputes between them must be referred to the shop manager. A foreman has power to depart from his instructions as contained on the drawings and premium cards, but is expected to advise the departments concerned if he does so, and, naturally, is expected to show good cause for his action.

Inspection of work is in the hands of another department, whose instructions are to accept or reject work on its merits only, and to allow no consideration of shop urgency to influence the passing of any material. The Inspection Department is responsible to the management only. It is a pleasure to us to see the definiteness with which the duties and spheres of these various departments are laid down. Examples of workshop management in which there is an indefiniteness in the division of duties are, we fear, not uncommon. Too often responsibility is spread in a hazy way, and casual instructions from officials of one department to subordinates of another form a feature of affairs. Messrs. Barr and Stroud's procedure forms a welcome contrast to this type of management. Nothing but good can come from each man's job being stated in clear terms, and each man being given complete authority within the limits of that job.

Turning now to details of some of the methods employed in the factory for interesting and keeping in touch with the workpeople, we may first refer to the Shop Committee, which was mentioned above. This committee consists of a chairman and vice-chairman appointed by the firm, four foremen appointed by the foremen, and eleven members elected from among the ordinary employees by the workpeople themselves. These members represent various different departments, and are chosen by those departments independently from each other. The work of the committee is to discuss and decide competent matters relating to the well-being of the workpeople. It deals, for instance, with the workers' mess-rooms and similar matters, and administers the Distress Fund. This is a fund raised by a weekly levy of 1*d.* on all wages of more than 1*l.* a week, and ½*d.* a week on all smaller wages. An amount equal to the total levy is contributed by the firm. Of the money raised, a half-yearly contribution of not less than one-third, and not more than two-thirds of the half-yearly total is granted to infirmaries and convalescent homes. The remainder forms a fund out of which grants-in-aid of distress are made to employees of the firm and their dependants. An investment of 500*l.* has been made to serve as a reserve for emergencies.

Another works organisation, existing for the good of the employes, is the Sick Benefit Society. Membership of this society is voluntary, but we believe it embraces the great majority of the workpeople. The object of the organisation is to distribute aliment to its members in case of sickness or disablement. Distribution is limited to 156 working days a year. A membership fee of 6*d.* is charged on entrance, and afterwards a weekly subscription, the amount of which varies with the member's wages. For instance, those whose standard pay does not exceed 10*s.* a week, contribute 1*d.*, and those whose standard pay is over 1*l.* 10*s.*, contribute 4*d.* a week. At the end of every year any surplus funds the society may have in hand are distributed among the members, and a fresh start is made for the next year. It will be clear that this society, which has been in existence for many years, covers, to some extent, the same ground as the National Health Insurance Act. The coming into force of that Act did not, however, cause an abandonment of the society, and sick employees now receive the two benefits.

A suggestion scheme is carried on in the works with considerable success. Like other activities of Messrs. Barr and Stroud's, it is managed in a workmanlike way. The matter is in the control of a special committee, made up of members of the staff, which holds frequent meetings. Suggestions which are accepted as being of value are granted awards of a sum not greater than 5*l.* Inventions or improvements considered to be of such value as to warrant a larger sum than 5*l.* have to be reported on by the committee to the firm. The matter of a greater award, or the taking out of a patent, is then considered. The suggestion scheme has been in operation since 1906, and the number of suggestions and awards has varied considerably in the different years. Over the whole period, however, the ratio of the number of awards to the number of suggestions has kept fairly constantly in the neighbourhood of 0·3. The latest year of which we have details is 1916. The number of suggestions was 477, which is considerably greater than in any earlier year. The number of awards was 150, of an average value of 1*l.* 6*s.*

Before leaving the question of the administrative methods in use in Messrs. Barr and Stroud's works, we wish to say something of the treatment of the apprentices. No odd-boy labour is employed in the factory at all. All boys are apprentices, and receive a proper training. They are not indentured, but are expected to spend the full training period of five years with the firm. There is a bonus scheme in operation in connection with the apprenticeship course. It is worked through a system of marks which are awarded for regular time-keeping at the works and for attendance and the results obtained at evening classes. A boy attending three classes of two hours per class per week, and making 100 per cent. in attendance and class work, and also not losing any time at the works, would get 200 marks. A boy attending two classes of one hour per class per week, and making 75 per cent. in attendance and 50 per cent. in class work, and also losing half-an-hour per week in the works, would get 55 marks. Bonuses are paid every week at the rate of 6*d.* a week per 50 marks for gains of 50 marks and over. The annual returns are made up during the early summer, and form the basis for a fixed rate of weekly bonus throughout the succeeding year.

In addition to the bonus system there is a scheme in operation for the higher training of apprentices. Under this scheme an examination to test workshop capacity is held each year in August. It is confined to apprentices of 17 years of age and over in their second, third and fourth years' of apprenticeship. On the results of this examination, coupled with the results obtained under the evening class bonus scheme, and the departmental manager's report, the apprentices are divided into two groups, the members of the first of which obtain leave to attend day classes at the Technical College or University, and also to attend day tuition courses in the works during working hours. They also have an opportunity of qualifying for a gift of tools at the completion of apprenticeship and of obtaining training in a wider range of shop departments to increase their shop experience. Apprentices of the second group obtain the last of these concessions. A special official of the firm deals with the works' tuition courses, and generally looks after the apprentices who have qualified for higher training. Fuller details of the system for the training of apprentices which is in operation at Messrs. Barr and Stroud's works will be found in an article which appeared in our columns about two years ago.* This article was written by Mr. Neil J. Maclean, Messrs. Barr and Stroud's works manager and one of the directors of the company. A study of the article will throw additional light on the spirit underlying the treatment accorded to Messrs. Barr and Stroud's employees, to which we have referred in earlier paragraphs.

In concluding our account of the various ways in which the firm shows an interest in its workpeople, we should say that there is a miniature rifle club in connection with the works, a range 25 yards long in the works canteen being used. The rifles were presented by Dr. Barr, and various cups and trophies have been given for competition by Dr. Stroud, Mrs. Jackson and others. The club is affiliated with the National Rifle Association, and is a member of the Glasgow Miniature Rifle Club League. Before concluding this section we should also say that a very interesting procedure in connection with Workman's Compensation is adopted by Messrs. Barr and Stroud. The firm undertake their own compensation, and a feature of the scheme is the appointment of a works doctor. The matter is of very considerable interest. It has resulted in a very large reduction in the number of accidents involving compensation, and in an intensifying of the good relationship between the management and men through the sympathetic attitude of the Doctor employed by the firm. We cannot deal with details of the matter in this general article, but in view of its importance, propose to return to it later. In our next part we will proceed to a description of the shops and their equipment.

(To be continued.)

THE EXCUSABLE MAN.

It was Euclid who presumably started the practice of taking things for granted, although the custom may be of much greater antiquity than the date of this Greek geometrician. His axioms and postulates cut out all the argument which otherwise might have acted adversely to the development of the science. In more modern times the majority of folk have to take a very large proportion of things on faith, if they did not take most things for granted there could be no organised effort of any kind. It is perhaps more this matter of taking things for granted which separates the practical from the academic view. Basic fundamentals and scientific analysis do not lack interest or utility, but in practical affairs assumptions needs must be made, for they are essential to production. Experience based upon subconscious comparison usually gives some warning when it is necessary to consider fundamentals, the novel, for example, always calls for original consideration, but in most trade connections practice proven by experience has the greater influence. A settled habit of taking things for granted has another side not so pleasant, short of the intuition which senses or forestalls mistake, troubles are bound to arise.

* See Engineering, vol. ciii, page 583.

In organised manufacture or mechanical production all processes follow on some previous work, the material, for example, has to be taken for granted in the majority of instances. Manufacture as distinguished from handicraft has the quality of interdependence very marked, responsibility is sectionalised and gives rise to problems complex and peculiar. It is more difficult to fix blame, the more sectionalised the processes the greater the difficulty in tracing fault. Supervision which assumes correct product must rely upon skill at all stages, otherwise continuous checks and counter checks are essential.

While the habit of taking everything for granted leads its possessor into queer places, the attitude of taking nothing for granted involves worry and vexation of spirit quite unwarranted. The quality of mind given by training and experience which is able to separate the essential from the routine is invaluable in administration. Much of the burden of management is the unremitting watch which it has to keep, the cultivation of that critical mind which, while not taking too much for granted, can yet shoulder the responsibility for others. The most reliable are apt to trip. The worst man possible is the individual who seems to exist for the divination of possible spectres which vanish under the practical handling of the competent. Somewhere between two extremes is said to lie truth, it is, anyhow, certain that in the same territory lies sense.

One of the most annoying occurrences is the excuse which springs from taking all things for granted. Faced with an error traced to one individual the explanation tendered invariably involves someone else, whose preparation was taken for granted, or whose word was accepted in similar case. Many casualties have resulted from unsuspected delinquency because something or other was without question taken for granted. The cure for the trouble is delegation of individual responsibility which modern methods of manufacture by their very spirit tend to lift from individual shoulders, it is perhaps the most valid criticism of sectionalised process, that it removes direct responsibility from the individual.

The excusable man is not uncommon, he is never short of a four-square cast-iron reason for every mistake, never under any circumstances, even when caught out *flagrante delicio* will he admit himself in the wrong. The concoction of a valid excuse, like all other invention, demands original thought and much skill, it indicates very fair mentality. To a superior this attitude of justification is the most irritating of all happenings. Mistakes will happen, but when acknowledged the sting is taken from rebuke, owning up is perhaps ignominious but is morally courageous, and is by no means moral surrender. It may even add to reputation, while it certainly adds to character.

Shuffling off responsibility is symptomatic, it indicates poor human material, the competent are glad to shoulder responsibility even if it involves the mistakes of others; for excuse is weakness; it is an attempt to justify error by palliation. Worse even than the man who will argue whenever he gets an order, is the man whose fertile brain concocts a plausible excuse, "telling the tale" is what he calls it in moments of confidence, and the more he is taxed the less will he admit fault. Every production organiser knows the type (it is to be feared that he is peculiarly English) who were and are among the most stubborn delinquents. There are those who commit mistake with intent, previously inventing the all-sufficient excuse if discovered. Parliamentary government itself is suspect in this connection, a legislature seems sometimes to exist for the purpose of excuse; like diplomacy there is a sense in which public speech can serve to hide truth and find grounds for casuistry. The terminological inexactitude is not confined to politics, but is more or less everywhere current. Usually the delinquent finds someone else to blame, we are all children of Adam in this sense, the most barefaced invariably put up a defence of some sort or another.

If possible, there is even a worse attitude, it is that of professed penitence, admission in the hope of remission, pleading guilty to diminish sentence; this attitude can be more reprehensible than argumentative excuse. Exactly where to draw the line is one of the more complex problems of administration, a judicial balance with a leaning to disbelief, in short, the magisterial mind is rather useful. Some sort of a case can be made out for anything given the type of mind inclined to special pleading. Some of this in productive connections is extremely good and able, self-hypnosis by repeated conscious effort is not confined to advocacy of ideals, nor of grievance nursed in silence.

After all, the special virtue of competence is an absence of need for excuse, it is human to err, but experience and training, perchance more especially the elusive faculty of judgment, give the overall sight essential. At all events competence is not altogether a matter of knowledge, it demands the same fertility of mind which distinguishes the excusable man, save that the mentality is more directly useful.

THE "B.H.P." AEROPLANE ENGINE.

On pages 136 and 137 we reproduce drawings and photographs of the 200-h.p. "B.H.P." aero engine designed and constructed by the Galloway Engineering Company, Limited, of Dumfries and Kirkcudbright. One of the first of these engines was fitted in a machine which was flown to France in the autumn of 1916. A glance at the photographs reproduced in Figs. 1 and 2, page 136, will show that the engine is exceptionally clean in design, due to the comparative absence of projecting parts, and that the adoption of overhead valve gear gives a narrow, compact engine, but, of course, increases the height to some extent. The engine is of the six-cylinder, double-ignition water-cooled type, and the cylinders are 145 mm. (5·71 in.) in diameter with a stroke of 190 mm. (7·48 in.). The output at the normal speed of 1,400 r.p.m. is 240 brake horse-power. As will be seen from the drawing reproduced in Fig. 3, page 137, the cylinders are arranged in two blocks of three each. Each block unit consists of a single aluminium casting comprising the cylinder barrels, combustion chambers, valve guides and seatings, and water jacket for the cylinders and combustion heads. Large openings, normally closed by screwed cover plates, are left for access to the water-jacket spaces. The cylinder liners are of forged steel, machined all over and screwed into the barrels, the screwing extending for the whole length of the part within the barrels. The lower ends of the liners are formed with heavy flanges, which are fixed to the crank-case by steel studs, and also by the bolts which support the main bearing caps. The water connection between the two blocks is effected by a coned joint with a rubber ring and clip.

Sections of the pistons are given in Figs. 3 and 5. They are cast from a special aluminium alloy, and are ribbed, as shown, for strength and also to assist heat radiation. Three cast-iron rings are fitted to each piston, and just below the bottom ring groove a recess is formed which directs the surplus oil to a series of holes through the piston, whence it drains into the sump. The gudgeon pins, which are hollow, are made from a special alloy steel, case-hardened all over, and split at each end. They are prevented from rotating in the piston by a double cone expander, shown in Fig. 3, and are further secured by a set screw, inserted through one of the lugs in the piston, engaging with a hole in the pin. A locking plate is provided to prevent this set screw from slacking. The connecting rods, which are of H section, are stamped from high-tensile steel, machined all over and carefully balanced to a specified weight. Plain phosphor-bronze bushes are used for the small ends, while the big end bushes, which are also of phosphor bronze, are lined with white metal.

The crankshaft is a hollow forging of chrome-nickel steel, accurately balanced and running in eight bearings in all. Seven of these bearings are of white metal in steel shells, and the other is a roller bearing mounted in the nose-piece of the crank-case adjacent to the propeller. In conjunction with this roller bearing is a double ball thrust which takes the whole of the end thrust due to the propeller. The arrangement is clearly shown on the left of Fig. 3. The two end main bearings are housed in the end walls of the crank-case, which is split horizontally along the centre line of the crankshaft, and the intermediate bearings are carried by webs formed in the upper half of the casing. As will be seen, the intermediate bearings are entirely independent of the lower part of the crank-case. The caps for these bearings are of aluminium strengthened by steel plates locked in place. The bolts for the bearing caps pass upwards right through the crank-case, and are used for holding down the cylinder liners. Collars on the bolts bear on shoulders in the bolt holes, and dowels on the bolts prevent them from rotating when the bearing cap nuts are tightened up. A tapered sleeve ground and keyed on to the crankshaft, is provided for carrying the propeller hub, which is serrated internally to correspond with external serrations on the sleeve. The position of the sleeve on the shaft is, of course, determined by the key, and the serrations on both the sleeve and the hub have one double tooth, so that the hub will only fit on the sleeve in one position. This accurate location is necessary, as the hub carries the pointers used for timing the valves and ignition. One of these pointers can be seen on the inner face of the hub in Fig. 3. The crank-case is a casting of aluminium alloy split horizontally, as above mentioned, and extended forwards to form the nose-piece, and backwards to form part of the casing for the timing, and other, gears. Brackets, best shown in Fig. 1, are formed on the left-hand side of the upper part to carry the magnetos and their driving gears. Three "breathers" of diamond section are fitted on the right-hand side, as shown in Fig. 2. The lower half of the casing is used mainly as an oil catcher, and, as will be seen from Fig. 3, the bottom slopes downwards from each end towards the centre, so that at any possible inclination of the aeroplane, the oil will drain into a cylindrical well formed in the centre of the base. The oil well is fitted with a removable filter, and from it a steel pipe leads to the scavenging oil pump, which we shall refer to later when describing the lubrication system.

The timing gears, which are at the rear end of the crank-case, are shown in Fig. 4. As will be seen the vertical shaft, which drives the camshaft, is itself driven from the crankshaft through an intermediate idler wheel placed above, and slightly to the left of, the centre line of the crankshaft. The object of this slight set-off is to enable the exhaust valves to be operated directly by cams on the camshaft without the use of rockers. The vertical shaft is hollow and in two pieces connected by splined portions, and at the upper end a bevel pinion having 16 teeth engages with a bevel wheel with 32 teeth on the end of the camshaft. This part is best shown in Fig. 3. An extension of the lower end of the vertical shaft drives the oil and water pumps as shown in Fig. 4. The camshaft is of hollow steel, and the cams, which are each separate, are keyed and pinned in place. As will be seen in all the illustrations, it is completely enclosed in two skeleton aluminium casings, one of which is fitted to each cylinder block; an oiltight gland is provided between the two casings. Long rectangular openings, normally covered by screwed plates, on both sides of the casings, give access to the valves, and further access is obtained through six circular openings on top of the casing. These circular openings are covered by plates which carry the rockers operating the inlet valves as shown in Fig. 5. The camshaft runs in four phosphor-bronze bearings lined with white metal, and the thrust of the bevel drive is taken on a ball bearing fitted at the rear end of the shaft close to the gears.

There are two exhaust valves, 46 mm. in diameter, to each cylinder, and these, as previously stated, are operated directly by cams on the camshaft. The upper end of each of the valve stems is screwed to receive a steel tappet, which is hardened on the face against which the cams work. The under side of the tappet is serrated, and this face engages with a similarly-serrated steel housing, which carries the springs and is prevented from turning by a key fitting into a slot in the valve stem. To adjust the valves, the cap is raised and the steel tappet rotated in the required direction. When the cap is allowed to fall again, its serrations mesh with those on the tappet and prevent any further movement. By this means a fine adjustment of the tappet clearances is obtained. A similar method of adjustment is used for the inlet valves, of which there is only one per cylinder. These valves are of the trumpet type, 69 mm. in diameter, and they are operated by case-hardened steel rollers on the ends of the valve rockers, the other ends of the rockers being operated by the inlet cams, as is clearly shown in Fig. 5.

The cooling water is circulated by a centrifugal pump located below the timing gears and driven directly by an extension of the vertical shaft. The arrangement is illustrated in Fig. 4, and it will be seen that the pump impeller rotates in a horizontal plane. The pump discharge is 31 gallons per minute, and the water is delivered to each of the two jacket blocks through the pipe seen in Fig. 1. The water leaves the jacket through the connection shown in the upper part of Fig. 2, and, after passing through the radiator, is returned to the pump through the suction connection which is arranged to take a rubber tube as will be seen in Fig. 1. Forced lubrication, on the dry sump principle, is employed throughout the engine. The oil pump, which is also driven by the vertical shaft, as shown in Fig. 4, draws oil from the storage tank and delivers it at a pressure of about 20 lb. per square inch through a filter into a pipe running along the whole length of the upper part of the crank-case on the right-hand side. From the pipe it passes through oil leads drilled through the webs of the crank-case to the main bearings, and thence through channels in the crankshaft webs to the

200 H.P. "B.H.P." AEROPLANE ENGINE.

CONSTRUCTED BY THE GALLOWAY ENGINEERING COMPANY, LIMITED, ENGINEERS, DUMFRIES, N.B

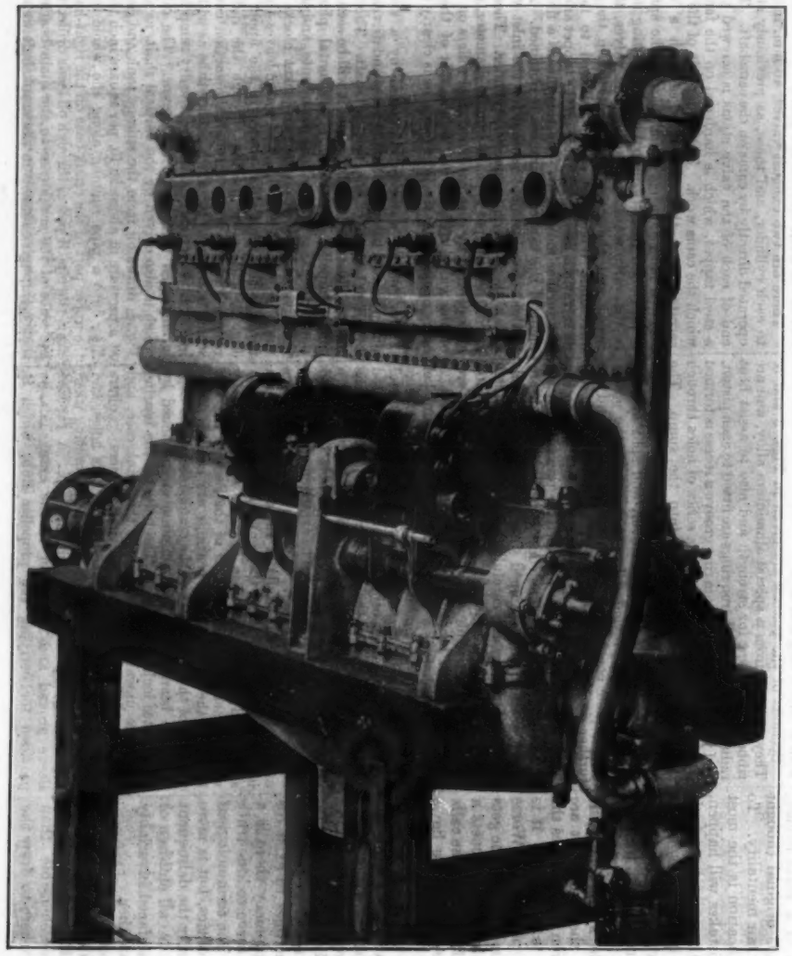


FIG. 1.

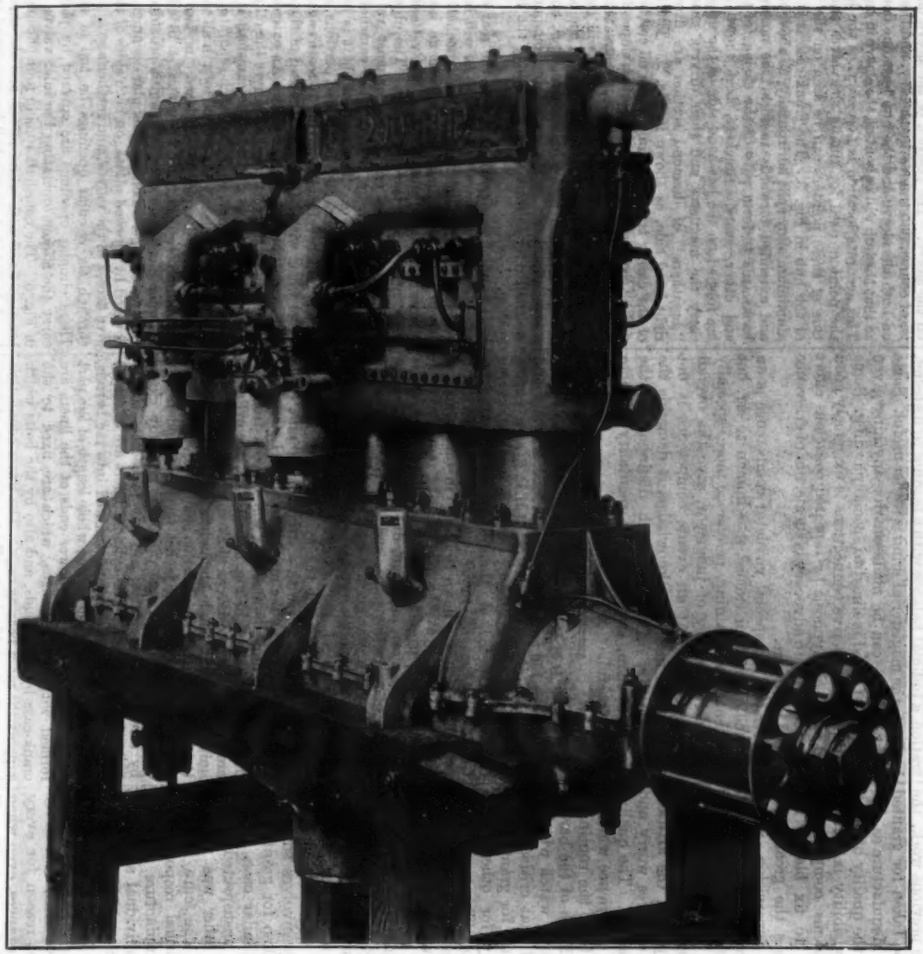


FIG. 2.

crank-pins. The cylinder walls and gudgeon pins are lubricated by oil thrown off from the crank-pins, as also is the drive for the magnetos, &c., a hole being cored out in the side of the crank-case for this purpose. The oil which drains into the crank-case sump is drawn off by a second pump, known as the scavenge pump, and returned to the main storage tank or cooler; the connection from the sump to the scavenge pump is shown in Fig. 3. At the forward end of the main supply pipe the oil pressure is reduced to about 10 lb. per square inch by passing through a needle valve, and, at this pressure, it rises through the vertical steel pipe, shown in both Figs. 2 and 3, to the front bearing of the camshaft. Some of the oil entering the hollow camshaft lubricates the other camshaft bearings, and some passes out through holes in the cam faces to lubricate the cams and tappets. The surplus oil from the front casing block passes through a large pipe into the base of the rear block, whence it descends through the hollow vertical shaft at the rear of the engine, into the crank-case, lubricating the bevel gears, and other gearing, on its way. Both oil pumps are of the gear type, and the capacity of the scavenge pump is some 40 per cent. greater than that of the supply pump so as to ensure the crank-case sump being kept dry.

Two type 48 R.A. "Zenith" carburettors are mounted on the right-hand side of the engine, and hot-water muffs are fitted to the carburettors and the inlet branches. Each carburettor is connected to an inlet manifold supplying a group of three cylinders, but the manifolds are themselves connected by a ¼-in. bore union to equalise the pressure in each. The carburettors are fitted with altitude control levers for correcting the effects of changes in air density at different heights, and the control levers and compensating devices of the two carburettors are interconnected. The two magnetos are of the B.M. 6 "Fellows" type, and two independent sparking plugs are fitted at opposite sides of the combustion chamber of each cylinder, as shown in Fig. 5. The standard timing of the ignition is arranged for a maximum advance of 32·5 deg. before the top dead centre, and, numbering the cylinders consecutively from the

200 H.P. "B.H.P." AEROPLANE ENGINE.

CONSTRUCTED BY THE GALLOWAY ENGINEERING COMPANY, LIMITED, ENGINEERS, DUMFRIES, N.B.

Fig. 3.

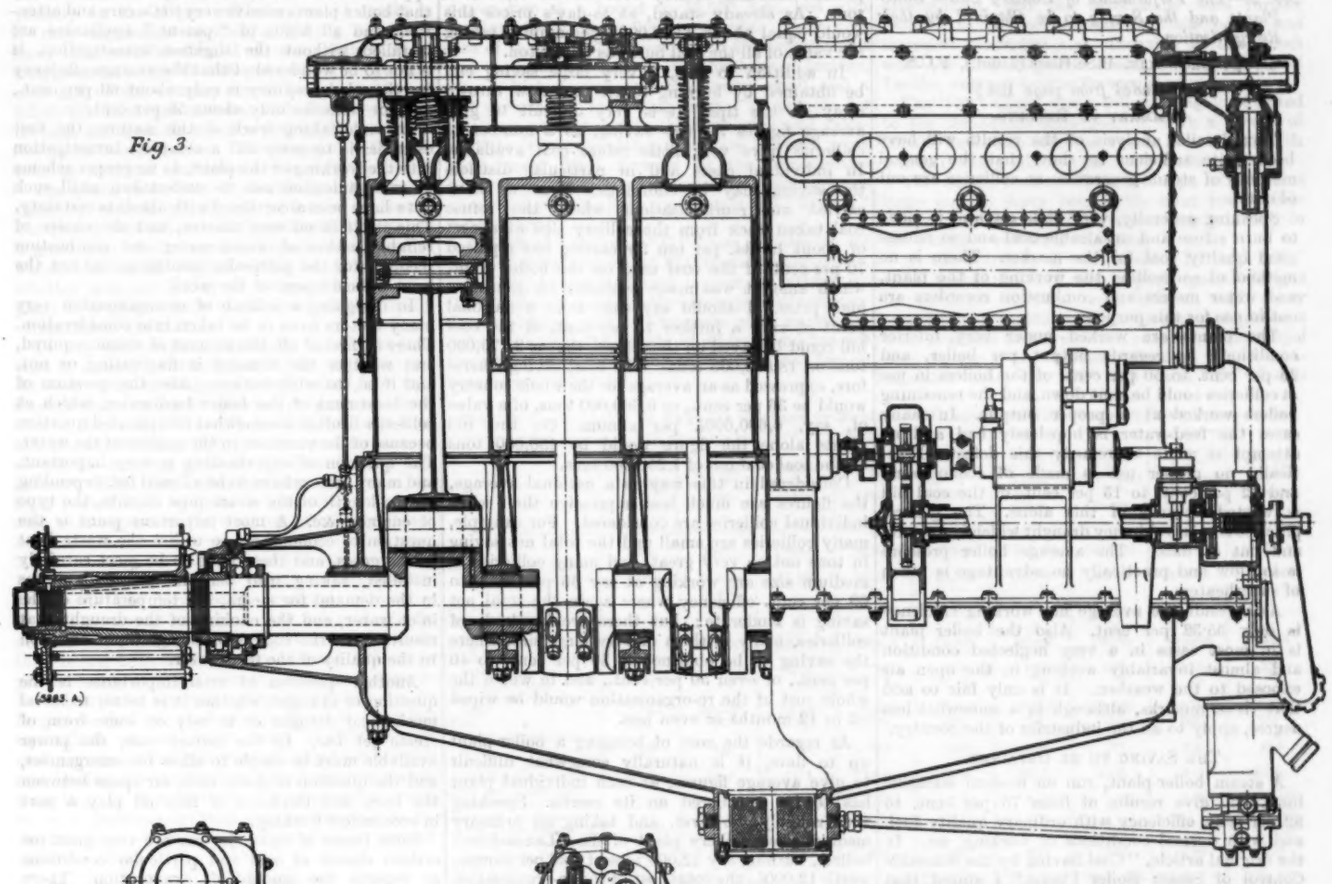


Fig. 4.

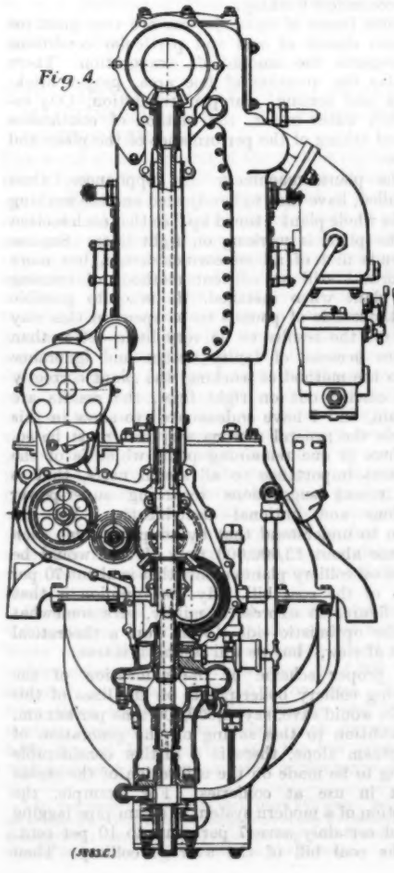
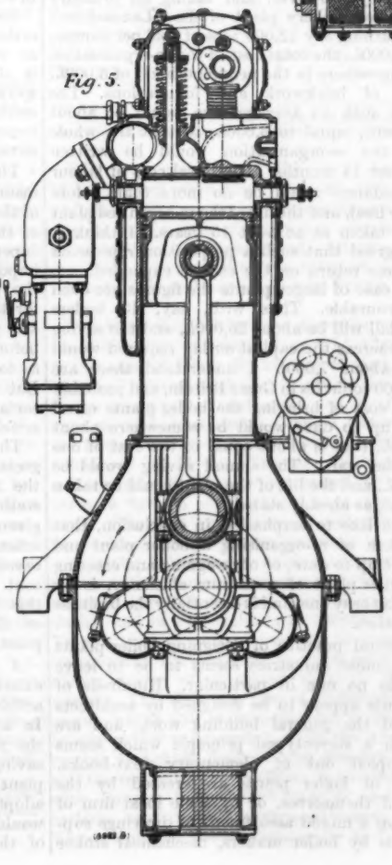


Fig. 5.



propeller end, the order of firing is 1, 5, 3, 6, 2, 4. The fuel consumption of the engine is given as 140 pints per hour, of petrol having a specific gravity of 0·72, which works out to 0·58 pint per brake horse-power-hour, and the consumption of lubricating oil (Vacuum B.B.) is 7 pints per hour, or 0·029 pint per brake horse-power hour. The total weight of the engine without oil or water is 605 lb., and the total weight in running order, less fuel and oil, but allowing 0·65 lb. per brake horse-power for the cooling system, is 767 lb. We append a table giving the weights of various parts of the engine and showing the percentage of each to the total weight :—

Description of Part.	No. per Set.	Weight of Complete Set in Lb.	Percentage of Total Weight.
Cylinders complete with water jackets	6	160·58	26·5
Crank-case, top half	1	108·96	18·0
Crank-case, bottom half	1	47·35	8·0
Crankshaft	1	107·0	17·8
Propeller hub, complete, including thrust race	1	15·0	2·5
Camshaft	1	14·29	2·4
Pistons, with rings	6	35·37	6·0
Connecting rods	6	32·0	5·5
Valves, inlet and exhaust	18	23·99	4·0
Induction pipe	1	2·15	0·4
Carburettors	2	8·0	1·4
Magnetos	2	34·19	5·8
Ignition wiring, with cable carrier tube	12	1·06	0·2
Water and oil pumps	1	9·77	1·6
Water pipes	1	1·38	0·2
Air pump	1	·851	0·1
Miscellaneous	—	3·0	0·5
		605·0	100·0

HYDRO-ELECTRIC POWER PLANT ON THE WALCHENSEE.—According to the *Barrzeitung*, the Bavarian Parliament resolved, on May 27, unanimously to proceed without delay with the completion of the projected power plant on the Walchensee, and of the 1,270 km. of power-transmission lines all over Bavaria in connection with this and other schemes. The resolution was passed in view of the want of employment and the dearth of coal, and in spite of the enormous outlay now involved.

EXACT DATA ON THE RUNNING OF STEAM BOILER PLANTS.

No. 2.—*The Performance of Colliery Steam Boiler Plants and the Saving to be Obtained by their Reorganisation.*

By D. Brownlie, B.Sc.Hons.(Lond.), F.C.S.

(*Concluded from page* 104.)

Summary of Results.

The detailed analysis of the results will have been quite sufficient to show that the general methods of steam generation at collieries are out of date.

Speaking generally, very little attempt is made to burn refuse and unsaleable coal and so release good quality coal for the market. There is no method of controlling the working of the plant, and water meters and combustion recorders are not in use for this purpose.

The plants are worked under very inferior conditions as regards output per boiler, and 25 per cent. to 50 per cent. of the boilers in use at collieries could be shut down, and the remaining boilers worked at a proper output. In many cases the feed-water is hopelessly bad and no attempt is made to remedy this defect. Practically no proper use is made of economisers, and 12 per cent. to 15 per cent. of the coal bill is wasted because of this alone. The general practice is to use chimney draught which is wasteful and out of date. The average boiler pressure is too low and practically no advantage is taken of superheaters.

As a result the average net working efficiency is only 55·52 per cent. Also the boiler plant is in most cases in a very neglected condition and almost invariably working in the open air exposed to the weather. It is only fair to add that these remarks, although in a somewhat less degree, apply to all the industries of the country.

The Saving to be Obtained.

A steam boiler plant, run on modern scientific lines, will give results of from 75 per cent. to 82 per cent. efficiency with ordinary quality fuel, and with normal conditions of working, &c. In the original article, "Coal Saving by the Scientific Control of Steam Boiler Plants," I stated that for all practical purposes 75 per cent. net working efficiency may be taken as the figure to be obtained on continuous performance. This, of course, applies to all industries, but for collieries only I should say that a better figure would be 70 per cent., which will give ample margin.

The reason of the 5 per cent. difference is to allow for the considerable fluctuation in the quality of the coal burnt at collieries. That is to say, although generally speaking most of the coal burnt on a particular plant may be high class, there is always the liability that an entirely different quality of coal, or even refuse and most inferior coal, may be suddenly dumped into the fire-hole, because, for example, the supply of the ordinary quality has run short.

This variation is bound to reduce the efficiency to some extent, unless the firemen are exceptionally skilful. I may say these figures of 75 per cent., with 70 per cent. in the case of collieries, are based on our own experience of about ten years' work in re-organising boiler plants, and are not theoretical assumptions. Thus in the 100 tests, 13 plants are already working at over 60 per cent. efficiency, and the general conditions on these plants are not different to the other 87 plants as regards scientific supervision and equipment. Also the figure of 70 per cent. efficiency to be obtained applies to the 52 per cent. of high class coal burnt, and also to the 32 per cent. of medium quality, that is to say, about 84 per cent. of the coal burnt. It does not apply to the 16 per cent. of the purely refuse coals, where the efficiency may be only, say, 55 per cent. to 60 per cent. even under the best conditions.

Taking, therefore, the figure of 70 per cent. efficiency as the conditions which can be obtained by adopting scientific methods, and assuming the figure of 55.52 per cent. obtained on the 100 tests as typical for the whole colliery industry, the saving to be obtained corresponds to about 21 per cent. of the coal bill. This would be equal to a national saving of 3,900,000 tons on the present national colliery coal bill of 18,500,000 tons. As already stated, at to-day's prices this would equal about 3,900,000*l.* per annum, taking the value of all the coal burnt as 1*l.* per ton.

In addition to this, a very large saving can be obtained by burning refuse coal now thrown away on the tips. It is very difficult to give average figures for this saving, as a number of collieries have very little refuse coal available. In individual cases and in particular districts the saving may be enormous. Thus we have carried out reorganisations where the refuse coal taken back from the colliery tips at a cost of about 1*s.* 3*d.* per ton for carting has replaced 70 per cent. of the coal used on the boiler plant, which amount was made available for sale at a high price. I should say that from a national point of view a further 15 per cent. of the coal bill could be saved on these lines, that is 2,775,000 tons on 18,500,000 tons. The total saving, therefore, expressed as an average for the whole country would be 36 per cent., or 6,600,000 tons, of a value of, say, 6,600,000*l.* per annum. On the 100 plants alone the figure would be 450,000 tons on the toal coal bill of 1,250,000 tons.

Considered in this way as a national average, the figures are much less impressive than when individual collieries are considered. For example, many collieries are small and the total net saving in tons not so very great, and many collieries of medium size are working at say 55 per cent. to 60 per cent. efficiency where again the total net saving is moderate; but there are hundreds of collieries, many of them of very large size, where the saving to be obtained is 30 per cent. to 40 per cent., or even 50 per cent., and in which the whole cost of the re-organisation would be wiped off in 12 months or even less.

As regards the cost of bringing a boiler plant up to date, it is naturally somewhat difficult to give average figures, as each individual plant has to be considered on its merits. Speaking very roughly, however, and taking an ordinary medium-sized colliery plant of six "Lancashire" boilers, burning say 12,000 tons of coal per annum, worth 12,000*l.*, the total cost of the re-organisation will be somewhere in the neighbourhood of 5,000*l.*, inclusive of brickwork and foundations. The saving in such an average case would be about 30 per cent., equal to 3,600*l.*, so that the whole cost of the re-organisation would be written off in about 18 months. The total cost of labour and attendance would be no more than before (probably less), and the life of the re-organised plant could be taken as at least 15 years. I think it will be agreed that such a proposition represents a handsome return on the capital expended.

In the case of larger plants the figures are even more favourable. Thus with, say, 10 boilers the coal bill will be about 20,000*l.*, and the saving 6,000*l.*, whereas the capital outlay required would be only about 7,000*l.* I understand there are about 3,300 collieries in Great Britain, and probably the total cost of bringing the boiler plants of all of them up to date would be somewhere about 7,000,000*l.*, that is about equal to the cost of one day of the war. The annual saving would be 6,600,000*l.*, and the life of the plant could be taken as 15 years, as already stated.

I should like to emphasise, in conclusion, that the problem of re-organising a boiler plant and bringing it up to date, or of designing and erecting a new boiler plant of maximum efficiency, is by no means an easy one, and is essentially the business of a specialist.

The general practice of designing boiler plants to-day in most industries seems to be to leave the job to no one in particular. Hundreds of boiler plants appear to be designed by architects as part of the general building work, and are erected on a stereotyped principle which seems to be copied out of elementary text-books. Hundreds of boiler plants are erected by the works staff themselves, or by some local firm of builders, on a mixed assortment of drawings supplied gratis by boiler makers, mechanical stoker makers, economiser makers, seating-block manufacturers, &c., who are after all (and quite rightly) only concerned with selling their own special appliances. When this is coupled with the fact that boiler plants receive very little care and attention, and all kinds of "patent" appliances are installed without the slightest investigation, it is not to be wondered at that the average efficiency for the whole country is only about 60 per cent., and for collieries only about 55 per cent.

In undertaking work of this nature, the first essential is to carry out a complete investigation into the working of the plant, as no proper scheme of re-organisation can be undertaken until such data have been ascertained with absolute certainty. This itself is no easy matter, and the choice of reliable makes of water meter and combustion recorder for the particular conditions are not the least difficult part of the work.

In designing a scheme of re-organisation very many factors have to be taken into consideration. There is, first of all, the amount of steam required, and whether the demand is fluctuating or not, and if so, to what extent. Also the question of the treatment of the boiler feed-water, which at collieries is often a somewhat complicated question because of the variation in the quality of the water. The question of superheating is very important, and many factors have to be allowed for, depending on the length of the steam pipe circuits, the type of engines, &c. A most important point is the question of economisers to utilise the waste heat in the gases, and these have to be most carefully installed, taking into account the fluctuations in the demand for steam, the temperature of the inlet water, and the choking of the draught that results from the cooling of the gases, in addition to the quality of the feed-water.

Another question of vital importance is the question of draught, whether it is better to instal mechanical draught or to rely on some form of steam jet bar. In the former case, the power available must be ample to allow for emergencies, and the question of grate area, air space between the bars, and thickness of fires all play a part in economical working.

Some forms of steam jet bar are very good for certain classes of coal and particular conditions as regards the amount of evaporation. There is also the question of flue area, proper brickwork and setting, damper regulation, CO_2 recorder, water meter, the method of continuous record taking of the performance of the plant and so on.

The plant, machinery and appliances, when installed, have then to be adjusted and the working of the whole plant "tuned up" so that each section of the plant is working on right lines. Success depends first of all on correct design, but more important still on efficient methods of running the plant when installed. It is quite possible for thousands of pounds to be spent in this way and for the results to be very little better than before because of faulty design and ignorance as to the method of working the plant correctly But carried out on right lines, the results are certain, and I have endeavoured to show in this article the general reasons why this must be so.

There is one remaining point which is of the greatest importance to all steam users, that is the recent suggestions regarding super-power stations and national electrification. We are given to understand that by adopting some such scheme about 13,000,000 tons of coal would be saved on colliery plants alone, that is about 70 per cent. of the coal bill. My own opinion is that this figure, to express it mildly, errs somewhat on the optimistic side "even from a theoretical point of view," but we will assume it is true.

A proper scheme of re-organisation of the existing colliery boiler-plants on the lines of this article would save, say, 6,600,000 tons per annum. In addition to this saving on the generation of the steam alone, there is a further considerable saving to be made on the utilisation of the steam plant in use at collieries. For example, the adoption of a modern system of steam pipe lagging would certainly save 7 per cent. to 10 per cent. of the coal bill of the average colliery. Then

again, probably 75 per cent. of the collieries of the country are wasting vast amounts of exhaust steam from the winding and other engines, and the installation of mixed pressure turbines, especially at the larger collieries, would result in a very handsome economy. Taking all these facts into consideration, I do not think it is an exaggeration to say that 50 per cent. of the colliery coal bill of the country could be saved, that is 9,250,000 tons per annum, and the results are certain, and such as are now being obtained at a few up-to-date collieries. The saving of 13,000,000 tons by national electrification is problematical.

The question we have to decide from a national point of view is whether it is better to launch out into a vast scheme of electrification, in which a great part of the work is experimental, and of which the initial capital outlay is enormous, or whether it is not better to bring up the existing plant to a proper state of efficiency at practically a fraction of the cost.

In any case such a matter is so tremendous that it cannot be decided in a few months, and we seem to be in danger of being rushed into vast electrification schemes without proper consideration of the facts. After all, how do we know that it is not much better policy in the case of collieries to use the existing plant on the lines I have suggested? The Coal Commission, for example, have stated that no reliable statistics are available with regard to the working of colliery steam boiler-plants, and yet we are informed that over 70 per cent. of the colliery coal bill can be saved!

There are very few men indeed in this country who have had any really practical experience in fuel economy on up-to-date scientific lines, and the question of the saving to be obtained in this direction throughout the existing 600 or so power stations of the country does not seem to be taken into account. Also it appears to be forgotten that we shall always have to have the equivalent of at least about 15,000,000 tons coal per annum for low-pressure steam for heating and boiling, no matter how cheap electric energy may be. In any case the whole question seems to be a particularly vital one to the colliery industry, which is so largely dependent at present on steam plant.

THE DEVELOPMENT OF TURBINE MACHINERY FOR TORPEDO-BOAT DESTROYERS.*

THE trend of development of the turbine machinery fitted in destroyers of H.M. Navy has followed a very well-defined line of progress with a threefold object in view: (*a*) Reduction of weight of plant and space occupied; (*b*) more economical generation of power; (*c*) improvement in the manœuvring and sea-keeping capabilities of the vessel. All of these aims are, of course, strategical irrespective of any technical improvements which may simultaneously accrue. From (*a*) and (*b*) the advantages gained are increased storage capacity for fuel on the same displacement, or increased speed for the same fuel expenditure per ton-mile and from (*c*) greater facility in operating when engaged in action. The reduction in weight and space of machinery over the period under consideration is shown on accompanying table to have made great progress, and as regards (*b*) and (*c*) the introduction of gearing has effected a marked advance, albeit somewhat disappointing in the improvement in fuel consumption at high powers which was anticipated from the increased turbine and propeller efficiency, due to its employment.

Excluding the more or less experimental boats Velox, Cobra, Viper and Eden, the coastal torpedo boats were the first batch of vessels fitted with turbine-driven shafts. These were of 4,000 h.p. designed, but made 5,000 h.p. on trial. There were three shafts, the high pressure and intermediate pressure on the wings, each developing 1,000 h.p. at 1,350 r.p.m., and the low pressure, with a cruising unit forward of it, on the centre shaft developing 2,000 shaft horse-power at 950 r.p.m. These boats were quite successful, in spite of their high propeller revolutions, and they were followed soon after by the "Tribal" class, in which the power rose at a bound to 15,500 h.p., but with revolutions reduced to 750 per minute. These were also of the three-shaft design, but the arrangement was the now standard one for this type of turbine, viz., a high pressure on the centre shaft and a low pressure on each wing shaft. To provide for economy at slow speeds, high-pressure and intermediate-pressure cruising units, one on each wing shaft, were fitted forward of the low-pressure turbines and used in series with the main turbines at reduced powers. Both the coastals and "Tribals" were oil-fired.

In 1908 and 1909 the "G" Class (numbering 16) of coal-fired destroyers, of 12,000 shaft horse-power, was built, having a similar lay-out of turbines to the "Tribals" and with the same speed of rotation. The coal-firing was a retrograde step introduced owing to a doubtful supply of oil fuel, and has not since been repeated, owing to the fact that fuel oil became more plentiful.

The "K" and "L" Classes of 1911–13 were entirely of the two-shaft independent type, experience having shown that the economy of this design was not greatly different from the compound arrangement, and the revolutions were further reduced to 650 per minute, but the power was increased to 24,500 h.p. Included in this batch were the first all-geared boats, the Leonidas and Lucifer, engined by the Parsons Company.

The "M" Class, which followed, again reverted to the three-shaft arrangement, with a power of 25,000, and some of these vessels were fitted with geared cruising units on the wing shafts.

The flotilla leaders of 36,000 h.p., of which a large number have been built, next made their appearance, and were of similar design generally to the standard vessels of the class.

At the outbreak of war repeat "L" and "M" class boats, together with repeat special designs by different builders, were ordered, and many completed in record time, as designs and patterns were available and thereafter, except for the special designs, the "M" became standard for a considerable time, the "N" "O" and "P" Classes

TABLE I.—ANALYSIS OF AVERAGE RESULTS OF SUCCESSIVE CLASSES OF H.M. TORPEDO-BOAT DESTROYERS.

—	Coastals 1–36.	Tribals or "F" Class.	Beagle or "G" Class.	Acorn or "H" Class.	Goshawk or "I" Class.	Acasta or "K" Class, and "L" Class.	"M," "N," "O" and "P" Classes.	"R," "S," "T" and "U" Classes.	"V" and "W" Classes.
Year	1906	1907	1908–9	1909–10	1910–11	1911–13	1913–15	1915–18	1917–18
Designed shaft horse-power and developed	4,000	14,500 15,500	12,000	13,500	13,500	24,500	25,000	27,000	27,000
Number of shafts	3	3	3	3	3	2	3	2	2
Number of ahead turbines	4	5	5	5	5	2	3	2	2
How coupled	Direct	Direct	Direct	Direct	Direct	Direct	Direct	Geared	Geared
Designed Propeller revolutions	C. 350 W. 1,850	700–750	750	750	750	650	750	350	350
Boilers, number	2	6	5	4	3	4	3	3	3
Heating surface, square feet	7,864	32,500	24,000	19,200	19,410	27,000	24,600	24,700	24,700
Fuel	Oil	Oil	Coal	Oil	Oil	Oil	Oil	Oil	Oil
Weight of machinery, tons	103	442	345	310	291	386	374	410	425
Weight in pounds per shaft horse-power	57·7	64·0	64·5	51·5	48·5	35·3	33·6	34·0	35·3
Fuel per shaft horse-power hour, pounds	1·26	1·25	1·7	1·2	1·11	1·16	1·12	1·08	1·08
Heating surface per shaft horse-power	1·96	2·1	2·0	1·42	1·44	1·1	0·985	0·915	0·915
Boiler pressure, pounds per square inch	215	220	220	220	220	250	250	250	250
Length of machinery space	68 ft. 3 in.	157 ft. 6 in.	136 ft. 6 in.	106 ft. 9 in.	105 ft. 0 in.	119 ft. 0 in.	122 ft. 6 in.	122 ft. 6 in.	122 ft. 6 in.
Horse-power per square feet of floor area	3·25	3·8	3·14	4·95	5·0	7·5	7·6	8·25	7·5

Note.—The above figures are averages of many ships of each class, as each ship is tried under varying conditions of weather, trim, displacement, &c., and propellers are not indentical for all ships of each class.

The next class—the "H" or "Acorns," of 13,500 h.p., of which there were 20—was identical with the "Gs" so far as the machinery was concerned, except that oil-firing was reverted to and detail modifications introduced. Of this class was the Brisk, which marked the entry of the Brown-Curtis turbine and superheat into British destroyer work.

The three-shaft design was generally repeated in the succeeding "Goshawk" or "I" Class, except in the case of Hind, Hydra and Hornet, built by Messrs. J. Brown and Co., in which the "Brisk" design was repeated and in the vessels of this programme of special design. These latter included the Badger and Beaver, fitted with partially-geared machinery by Messrs. Parsons—the high-pressure and cruising turbines were geared to the low-pressure turbine shaft which drove the propeller shaft. The first application of reduction gearing for turbines for propulsive purposes in the Navy was in the Acheron and Ariel, by Messrs. Thornycroft, with Parsons independent impulse and reaction type of turbine, one on each of two shafts, and in the Archer and Attack, by Messrs. Yarrow, with a similar two-shaft arrangement for independent Brown-Curtis turbines using a rather higher degree of superheat than in the earlier vessels. This class was also of 13,500 shaft horse-power, whilst still maintaining the propeller revolutions at 750 per minute; while the power of the special two-shaft designs was somewhat higher and the revolutions about 650. A two-shaft design with Parsons independent impulse and reaction turbines was fitted in some special vessels of Messrs. Yarrow's design built subsequently to "I" Class. being virtually repeats so far as the machinery was concerned, although under stress of war conditions the cruising units were omitted, provision, however, being made for subsequently fitting them if desired.

The first regular series of the all-geared type commenced with the "R" Class, of the 1915 programme, in which the power was increased to 27,000 h.p., with propeller revolutions of 350. The gearing enabled the turbines to be reduced in size owing to the revolutions being raised to about 3,000 per minute in the high pressure and 2,300 per minute in the low-pressure turbines, and each set consisted of one high pressure and one low pressure, driving a common gear wheel on the propeller shaft. This arrangement has, owing to its great success, become standardised, and except in a few special cases all the ships of the later classes have been so fitted. The cruising turbines have also been replaced by an additional stage in the high-pressure turbine, which is bye-passed at full power, thereby simplifying enormously the pipe connections with practically no loss of economy at low powers. The "V" and "W" Classes have identical machinery, but as the ships are somewhat larger, the weight of the installation is slightly increased per shaft horse-power, although improved hulls have enabled the larger ships to attain the same speed without increase of power.

Table I gives some figures showing how the weight of the machinery has been reduced and also the fuel consumption. These figures have been improved upon in certain ships which have run their trials under favourable conditions of weather, draught, &c., but the data must be looked upon as average

* In our issue of March 31 last (page 362 *ante*), we gave an article on "The War Development of the Torpedo-Boat Destroyer"; the present article dealing with machinery should be read in conjunction with the former.

results for the class rather than optimum performances.

The conclusion of the war has naturally caused a pause in destroyer machinery development, but it will be seen from the table that the tendency all along has been to rate the steam generating plant more highly, to reduce the propeller revolutions and at the same time to ensure greater reliability by not sacrificing every other consideration to weight saving. The most fertile field for further improvement appears to be in the provision of highly superheated steam for the main engines, and now that the turbines are very greatly reduced in size, the difficulties of attaining this end lie principally in the boilers—the three-drum type usually fitted, not lending itself readily to this requirement.

So far the double-reduction gear has not been fitted, and it might be thought that this offers a further potential economy in that the propeller revolutions would be still further reduced; but it must be remembered that even with 350 r.p.m.—the propellers are so large as to be well below the keel line, and with the limited draught the scope in this direction is not wide. The only other source of improvement appears to be the reduction of steam utilised by auxiliaries and efforts in this direction are being undertaken. There is still much room for improvement in the steam consumption of the reciprocating machinery, and also of the small turbines latterly provided for this purpose, particularly at reduced loads.

In supplement to the general particulars we have given of the turbine machinery for the torpedo-boat destroyers built during the war, we give, on Plate IX, two views of direct-driven turbines, constructed by Messrs. William Beardmore and Co., Limited, Dalmuir, and on Plate X, two views of geared turbines manufactured by the Wallsend Slipway and Engineering Company, Limited, Wallsend-on-Tyne.

Fig. 1, on Plate IX is a view of the aft end of the direct-drive turbines of the Parsons' type for driving twin-screw destroyers of the "L" Class. These turbines are of the independent impulse and reaction direct-coupled type, and the illustration shows the astern nozzle control valves, the exhaust branches and the condensers in the same relative positions as they occupy in the ship. Fig. 2 is a view looking on the forward end of the same set of Parsons' turbine machinery, showing the ahead control nozzle valves, the adjusting bearings, the lifting guides and the closed exhaust valves on the turbines.

Figs. 3 and 4, on Plate X, illustrate the geared turbines of the Wild Swan, the last of 24 destroyers engined by the Wallsend Company during the war. Each set of the twin-screw all-geared turbines illustrated by Figs. 3 and 4 consists of a high and low-pressure turbine working in series and coupled to the pinion shafts by flexible couplings, the pinions being arranged one on each side of the gear wheel, which in turn is connected direct to the lines of propeller shafting. The astern-going turbines are incorporated with the low-pressure turbines. The turbines are of the Brown-Curtis type with wheel stages throughout both high-pressure and low-pressure turbines. By the adoption of the impulse type of turbine and wheel stages, large clearances between the rotating and stationary elements are permissible. Steam is admitted to the ahead and astern turbines through groups of nozzles, each group having its controlling valve. The number of groups of nozzles open to steam at any one time can thus be regulated to suit the condition of load under which the turbine is working and better economy in fuel consumption is thereby ensured at powers less than the full.

These more recent sets of machinery built have been constructed in a way that still further economises the steam at the low powers required at cruising speeds. To attain this object an additional cruising wheel stage has been fitted to the steam-admission end of the high-pressure ahead-going turbine, the size of nozzles and height of blading being made suitable to obtain good efficiency. These nozzles have their own independent control valves for steam admission. Further, an interstage valve of the slide-valve type with worm wheel operating gear, is placed between this cruising wheel stage and the first full-power wheel stage of the high-pressure turbine. This interstage valve in one position allows of the cruising stage working in series with all the high-pressure turbine stages, from low or cruising powers up to moderately high powers, or alternatively this valve in its other position, when the highest powers are being developed, allows the steam passing through the cruising stage to be by-passed to the third stage of the high-pressure turbine so as to ensure the continuous expansion of this steam.

With regard to the materials used it may be mentioned that the turbine casings are of cast-iron, the divisional diaphragms being of the same material with nozzle vanes of nickel steel cast in place. The whole of the rotating parts of the turbines are made from ingot steel forgings. The blading is of phosphor bronze material. The gearing is of the double helical type and the distance apart of the two sections of the gear wheel rim is sufficient to allow of central bearings being fitted to the pinion shafts to preserve the alignment. The gear-wheel rims, centres and shafts are made from ingot steel forgings conforming with Admiralty requirements. The gear cases are mainly of cast-iron, the lower portions or troughs are built up from steel plates and angles.

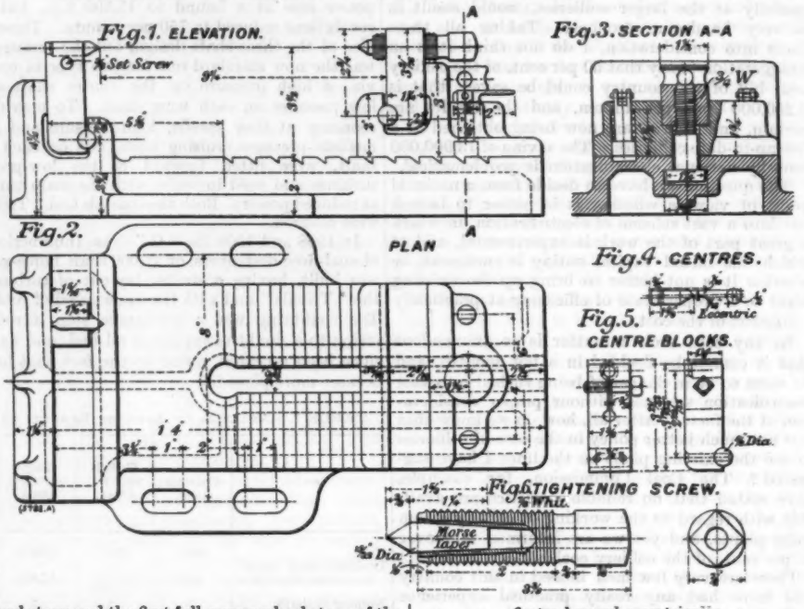
For the efficient and silent running of the gearing it is necessary that the means of lubrication should be as thorough as possible, and for this purpose sprayer nozzles, distributed at suitable intervals, are arranged to spray the oil direct on to the engaging teeth, thereby providing a film of oil between the surfaces in contact. The bearings for the turbine spindles, together with the bearings of the gear wheel and pinion shafts are also arranged to work under a system of forced lubrication.

The condensers are of the Weir "Uniflux" type embodying all the latest improvements; they are situated immediately underneath the low-pressure turbines, this position being one in which it was found that the condensers could be most readily accommodated, and naturally simplifies the drainage problem.

Fig. 5, on page 148, gives an illustration of two sets of geared Brown-Curtis turbine machinery for destroyers of the "S," "T" and "V" Classes, taken in the shops of Messrs. Beardmore at Dalmuir, where they were constructed. The view shows a high-pressure turbine with its double-helical pinion and flexible coupling, the pinion cover having been removed. Beyond is seen the low-pressure turbine with an astern element at the forward end, and the group of manœuvring valves mounted thereon.

THE "ELAND" MACHINE VICE.

CONSTRUCTED BY MESSRS. J. J. LANE, LIMITED, ENGINEERS, LONDON



In the foreground is shown a Michell thrust block assembled and a double-helical gear wheel.

"ELAND" MACHINE VICE.

On the present and opposite pages, we illustrate the "Eland" vice made by Messrs. J. J. Lane, Limited, of Phœnix Engine Works, Old Ford-road, E. 2. The feature of the vice is that it is constructed on the "three point of suspension" principle, the usual two jaws of a vice being replaced by the three sliding blocks, as shown in the general view of the vice, Fig. 8.

The drawing, Figs. 1 to 7, gives details of the vice. The base and movable swivelling block are made of cast-iron, the sliding blocks (Fig. 2) carrying the centres are of steel, with fitted case-hardened centres. It should be noted that provision for wear of the sliding blocks and therefore for correcting any want of line-ability of the centres is secured by making the centre (Fig. 7) of the two back centre blocks eccentric with the body; the eccentricity is $\frac{1}{16}$ in. and, therefore, by turning the centre-piece in the block adjustment for wear may be correctly made.

When preparing a piece of work such as a casting or a forging for the vice, it is only necessary to scribe a line on the marking-off table around a convenient part of the work in the correct relationship to the machining operation and parallel to the basis line. Two centre pop marks are made on one face of the work at a good working distance apart, and one pop on the opposite or approximately opposite face. These three pops may serve as the permanent basis for other machining operations, thus saving the time of the marker-off and setter-up, and further ensuring accuracy of the operations. In the case of accurate work or heavy work it is advisable to drill small holes in place of the centre pops.

Where the three-point system of holding work can be adopted, time is saved, as the work can be taken out of the vice and subsequently replaced for further operations, or it can be placed in a similar vice on another machine with a knowledge that with reasonable care the location will be accurate and correct for the succeeding operations; in fact, expensive jigs may under certain conditions be unnecessary.

A further advantage of the system is that it is not necessary to use much force when tightening up the work in the vice and therefore light castings or forgings

THE "ELAND" MACHINE VICE.

CONSTRUCTED BY MESSRS. J. J. LANE, LIMITED, ENGINEERS, LONDON.

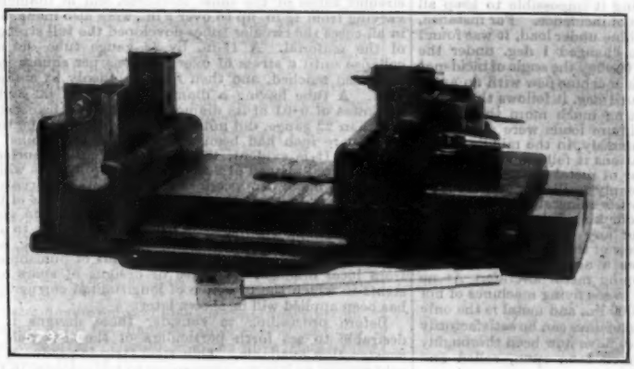


FIG. 8.

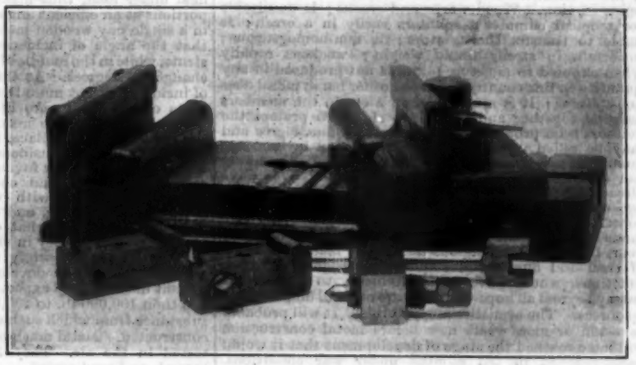


FIG. 9.

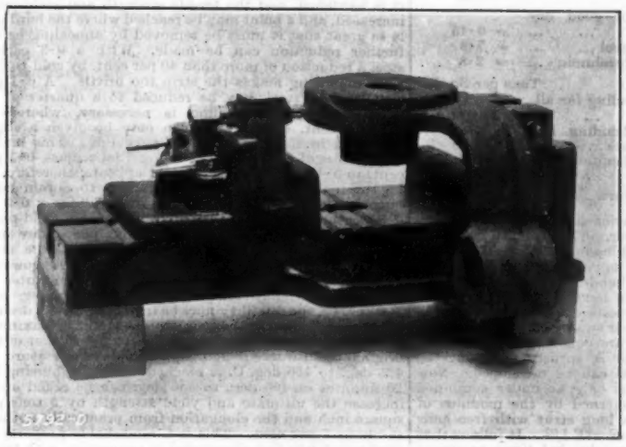


FIG. 10.

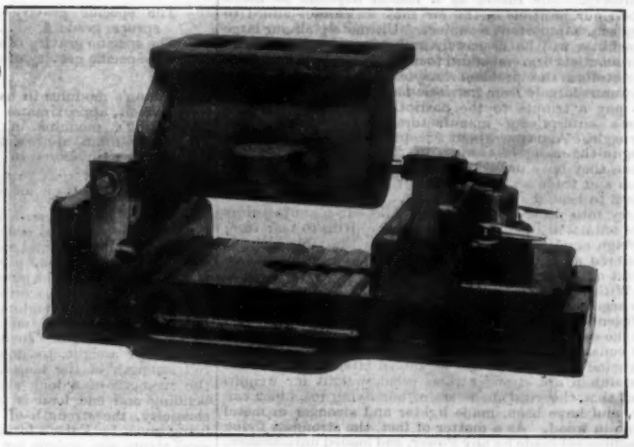


FIG. 11.

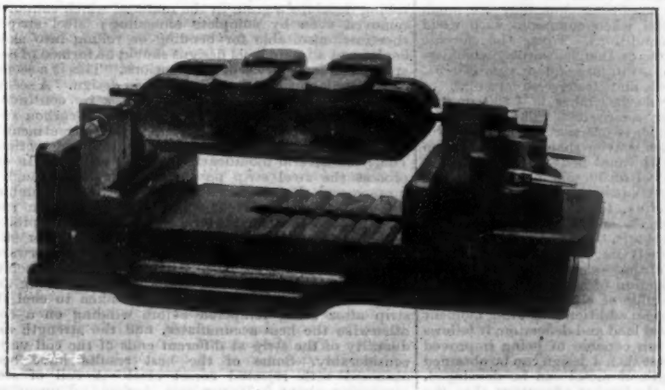


FIG. 12.

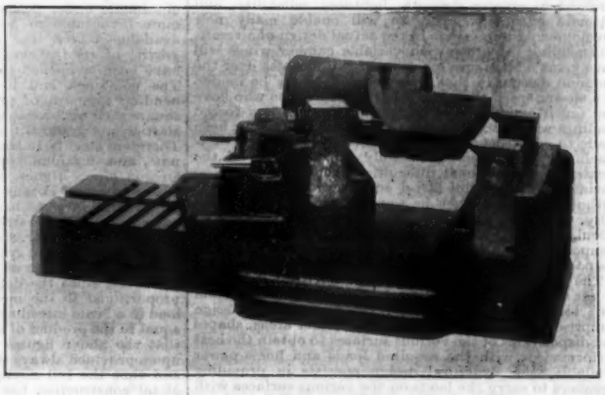


FIG. 13.

may be held without distortion, provided that the positions for the pops are judicially chosen.

The firm have, to meet the requirements of the machine-tool trade, put another model on the market, known as the "flat type" of vice. The three-point principle of gripping the work is retained, but the base has a flush top with slots cut at right angles to that in which the two-point blocks are mounted, this does away with the serrations across the bed, enabling a thinner base to be used, and makes the vice more compact and rigid without the loss of any of its advantages.

The vice is shown in Fig. 8 ready for work, in Fig. 9 the parts have been dismantled in order that a better idea of its component details may be obtained, whilst in Figs. 10 to 13 various castings, &c., are shown held in the vice ready for the machining operations; Fig. 13 shows clearly that irregular shapes may be secured.

The vice is suitable for use with the lathe, milling machine, grinding machine or drilling machine, and should prove of real service in the machine shop. A large number of the vices have already been put into service on war work.

HARDNESS AND RESILIENCE OF GOLD-COPPER ALLOYS.—In 1914 A. Portevin and J. Durand started an investigation of the alloys of gold and copper. The research was soon interrupted by the restriction placed upon the trade in precious metal. Meanwhile Kurnakov and Zemczuzny had continued their study of the transformation of these alloys. Portevin and Durand did not intend to resume their researches at the end of the war, but published a brief account of their preliminary results concerning the brittleness of these alloys in the *Revue de Métallurgie* of March–April last. It was known that jewellers have trouble especially with so-called red gold containing about 20 per cent. or 30 per cent. of copper. Brinell tests showed that the hardness increased much as the copper content was raised to 20 per cent., and diminished again on further addition of copper, more slowly and regularly. Shock tests, made in a Guillery machine, showed a corresponding variation in the strength, which diminished first and then increased, not so regularly, however. The compound Cu Au would contain 24·28 per cent. of copper, but the figures given by Portevin refer only to alloys the copper percentage of which increased in steps of 10 per cent. The specimen of 20 per cent. Cu, showing the lowest strength, had distinctly a needle fracture; in the alloy with 30 per cent. of copper the fracture was of the acanthus-leaf type. With more copper the fracture became granular.

METAL CONSTRUCTION OF AIRCRAFT.*

By A. P. Thurston, D.Sc., F.R.Aë.S., F.R.Met.S., M.I.A.E.

This war has been fought with machines made of wood, a most unsatisfactory material from a constructional point of view. Wood warps and cracks; is unsuitable for tropical climates; splinters easily in a crash; is liable to transfix the aviators; is non-homogeneous; uncertain in strength and weight; weakens rapidly when exposed to moisture; and is not produced in any quantity in this country. On the other hand, metal does not splinter; it is much safer in a crash, the members hanging together and forming a shield to protect the aviators; its properties are known to a fine degree and may be relied upon; it can be produced in immense quantities; and, moreover, metal members after breaking can still carry a considerable load. Many lives have already been saved by the use of metal bodies. A year ago over 1,000 all-metal machines had been used with success in the allied fighting line, but not one had been made in this country. Had the war extended into this year, however, a prodigious number of machines, made of steel and duralumin, exquisitely designed for their functions, would have been produced, to swamp the enemy beyond all hope—so great are our still undeveloped resources. The armistice stopped this. It will probably take ten or more years now before metal construction will have reached the stage of development that it would have reached in ten months under war conditions. It is hoped by drawing public attention to the problem, and by placing information at the disposal of firms interested, to hasten the development of this important industry. Our future as a nation depends so much upon our position in the air that we cannot afford to neglect so important a subject. Ultimately all our large machines will be of metal, and it is thought that no aeronautical firm can afford to neglect metal construction. Heretofore the problem has been tackled by manufacturers largely from patriotic reasons. It is a pleasure to pay a tribute to the patriotism and energy which these enterprising manufacturers brought into the struggle. Almost without exception there has been no dog-in-the-manger business in their policy. In many cases they have passed on generously exclusive information and trade secrets to hated rivals in order to assist them to beat the common enemy. That is the spirit to carry into peace conditions. While our manufacturers are animated by that spirit we have little to fear from foreign competition, provided always that this spirit is fostered and encouraged by wise and unselfish Government officials.

With regard to metal construction of aircraft, it may be argued that metal is too heavy to be used to construct efficient flying machines. The same argument was used in the early days of iron vessels; now wood is used only to construct small craft, and all large vessels are constructed of steel. It will be shown later that steel and duralumin are stronger than wood, weight for weight, and that the vital members of our flying machines can be, and have been, made lighter and stronger in metal than in wood. As a matter of fact, the strongest flying machine yet made by any Power, and loaded until broken, is a metal Avro machine constructed by Messrs. Vickers, and this machine is lighter than the standard wooden machine. The advantages of metal construction are not confined to greater strength, lightness, reliability, and ultimate cheapness. Its use will enable many new developments to be made in the actual design of aircraft. Thus, flying machines with variable camber wings will have great advantages for commercial purposes over the common design, in that these machines may be landed at a slower speed than any other type. Those who have had much experience of cross-country work and forced landings will appreciate this. Many attempts have been made to construct variable camber machines, and these machines have been successfully flown. Some of the greatest constructional difficulties encountered will be obviated by adopting metal construction. It was the author's intention when he took up the subject to deal fully with the whole problem, including methods of calculation. He soon found, however, that he would be compelled, from considerations of time alone, to limit his paper to a small portion of the subject.

The design of aircraft resolves itself into two more or less distinct problems, namely, the aerodynamical and the structural design. The aerodynamical design comprises the determination of the correct areas, shapes and dispositions of the various surfaces to obtain the best performances with the required loads and horse-power available—the structural design consists in providing members to carry the loads on the various surfaces with the required factor of safety. The most efficient structural design is one in which the required strength is obtained with the minimum weight of structure and the maximum ease and cheapness of production. Further requirements of an efficient design are durability under varied weather conditions, ease of repair, and safety in a crash. Heretofore, with a few notable exceptions, the vital members of the aircraft structure have been made of wood. The weight and strength of specimens from the same species of wood differ greatly. Spars for one type of machine were found to vary in weight from 6¼ lb. to 16 lb., and the strength varied in practically the same proportion. In addition, the strength decreases with the amount of moisture absorbed. Thus, the strength of spruce in compression decreases 230 lb. per square inch per 1 per cent. of moisture between 10 deg. and 25 deg. moisture. Wooden machines sand tested under the very favourable conditions of a dry workshop therefore showed a much greater strength than in the field. A sodden machine in the tropics may have only half the strength of the same machine when tested in the workshop at home. Moreover, owing to the disposition of wood to warp or split, particularly under tropical conditions, a wooden machine quickly gets out of truth and requires trueing up. Wooden wings deflect a great deal under load, thus making it impossible to keep all portions at an efficient angle of incidence. For instance, in a single bay wooden machine under load, it was found that the angle of incidence changed 1 deg. under the struts, while in the middle of the bay the angle of incidence changed 2½ degrees. As this machine flew with an angle of incidence of not more than 1 deg. it follows that some parts of the wing were lifting much more than other parts; moreover, the maximum loads were applied in the least favourable place, namely, in the middle of the bay. From these considerations it follows that there is a strong argument in favour of metal construction if it can be efficiently and cheaply utilised. We are an engineering nation with vast mineral resources and practically no timber, and our knowledge of high-grade steels is superior to that of any other nation. It is, therefore, sound policy in view of the vital importance of aeronautics to our safety as a nation that we should spend large sums in developing metal aircraft. At no distant date we may expect to see flying machines of not less than 100,000 lb. to 200,000 lb., and metal is the only substance from which such machines can be satisfactorily constructed. Metal machines have now been thoroughly tested in the air. They have been spun, rolled and looped, and sand tested.

The metals which are immediately available for metal construction are steel and duralumin, other alloys should be available shortly.

The specific gravity of good dry spruce, grade A	= 0·45
The specific gravity of steel ...	= 7·8
The specific gravity of duralumin ...	= 2·8
	Tons per Sq. In.
Young's modulus in bending for all steels, approximate	= 13,600
Young's modulus in bending for duralumin, approximate	= 5,500
Young's modulus in bending for spruce, A	= 715

(The modulus is, of course, less in tension.)

Hence, steel is 17 times heavier than good spruce, and duralumin is six times heavier. The strength of spruce in combined bending and end loading cannot be assumed greater than 5,500 lb. per square inch, or 2·45 tons per square inch, and the pure bending test should never be used for wood. Some errors have resulted during the war owing to pure bending tests only being taken. It follows that steel of 42 tons per square inch or duralumin of 15 tons per square inch are equal in pure bending, weight for weight, to grade A spruce, providing the full strength of the material can be developed. Now the strength of a long strut or spar under combined bending and end load is governed by the modulus of elasticity, the strength of a long strut with free ends being given by Euler's formula $\pi^2 E I/l^2$. It follows that steel struts are, weight for weight, 1·1 times as strong as spruce, and that duralumin struts are 1·2 times as strong as spruce, provided the full strength of the metal is developed. These figures relate to the best wood obtainable under peace conditions, but they are much more favourable to metal when compared with wood available under war conditions. Thus, the specific gravity of dry Oregon pine or Douglas spruce, which we have been compelled to use in large quantities, is 0·51. The combined end load and transverse strength or bending strength of grade B timber is 4,500 lb. per square inch or 2 tons per square inch. The modulus of elasticity of grade B timber is 625 tons per square inch. Therefore steel is 15 times heavier than grade B Oregon pine, and duralumin is 5½ times heavier than grade B Oregon pine. Hence, steel of 30 tons per square inch or duralumin of 11 tons per square inch are equal, weight for weight, in pure bending, to grade B Oregon pine, provided the full strength of the material can be developed. Further, steel struts are, weight for weight, 1·4 times as strong as grade B Oregon pine, and duralumin struts are 1·6 times as strong as grade B Oregon pine. Moreover, since the deflection of a beam under load is proportional to the modulus of elasticity and the end load in a beam introduces an additional bending moment equal to the product of end load and deflection, it follows that the above figures are capable of being improved upon, provided always that such a design can be obtained and that the full strength of metal can be developed. Metal construction has the further advantage that the metal may be disposed at a greater average distance from the neutral axis.

It may be argued, since the modulus of elasticity of all grades of steel is approximately the same, that the grade of steel to be used in struts is of no importance. This is not so in fact, because with mild steels small local damage causes local failure, whereas with higher grade steel local damage is of minor importance. The metal used in the construction of metal aeroplanes must be extremely thin if it is to compete in weight with wood. The most useful thicknesses for steel have been found to be 0·015 in., 0·018 in. and 0·022 in. Duralumin has the advantage over steel in that it is three times thicker, weight for weight. The chief difficulty with thin metal structures is local failure, due to local flexure, before the full strength of the material has been developed. A preliminary series of tests were made by Major Wylie on square tubes having flat sides 1½ in. wide which were 50 times the thickness of the metal. The tube was heat-treated so as to raise the elastic limit of the material to above 80 tons per square inch, but when tested by bending, the side in compression formed transverse corrugations at a stress of 25 tons per square inch, and these corrugations increased with increasing load, and finally caused failure at a stress of about 40 tons per square inch. When tested in compression the tube failed completely at about 25 tons per square inch as soon as the corrugations appeared. Further tests on circular tubes of the same thickness, and of diameters varying from 1⅝ in. up to over 2 in., were also made, and in all cases the circular tubes developed the full strength of the material. A 1¾-in. by 22 gauge tube did not collapse until a stress of over 110 tons per square inch had been reached, and then failed suddenly at a slight dent. A tube having a diameter of over 2 in. and a thickness of 0·01 of its diameter, which is considerably less than 22 gauge, did not fail until a stress of 100 tons per square inch had been reached, and then failed in tension. It is evident, therefore, that curved surfaces must be used instead of flat surfaces. From tests which have been made it appears that the radius of curvature should never be more than 20 times the thickness of the metal. This is unlikely to put any limitation on good design and will ensure the section standing up to the maximum strength of the material without failing, and make it capable of taking a fair amount of punishment from local damage. A series of designs of spars and struts in which the principle of longitudinal corrugation has been applied will be shown later.

Before proceeding to consider these designs it is desirable to set forth particulars of the materials of construction available. Thin steel strip is produced by cold rolling, as it is not economical to roll material in the hot state to less than 17 or 18 gauge. The hot rolled strip is usually first pickled and then cold-rolled to the thickness desired. As the metal is reduced in thickness it is hardened, and the tensile strength and yield-point increased, and a point may be reached where the hardness is so great that it must be removed by annealing before further reduction can be made. With a 0·3 carbon steel a reduction of more than 40 per cent. by cold-rolling after annealing makes the strip too brittle. A 0·1 per cent. carbon steel may be reduced to a quarter of its thickness before annealing is necessary, whereas a 0·8 per cent. carbon steel can only be given a slight reduction in thickness without annealing. This makes the process of cold-rolling costly and laborious—0·3 per cent. to 0·4 per cent. carbon steel appears, therefore, to be the most suitable quality in which to obtain large output with good strength. By cold-rolling a 0·3 to 0·35 carbon steel the tensile strength and yield-point may be increased up to about 65 tons per square inch with practically no ductility. This renders the strip unsuitable for rolling into useful sections. If, however the strip is tempered or "blued" for 15 minutes or 20 minutes at any temperature between 0 deg. and 450 deg. C., the ductility may be increased to any desired amount according to the temperature, and the maximum breaking stress and yield point do not fall to that of the original cold-worked figures until a temperature of 425 deg. to 450 deg. C. is reached. Usually blueing for 20 minutes at 400 deg. to 450 deg. can be relied on to increase the ultimate and yield strength by 5 tons per square inch and the elongation from practically nothing to about 7 per cent. This is a remarkable property of steel which was first discovered in connection with tubes and afterwards applied to steel strip.

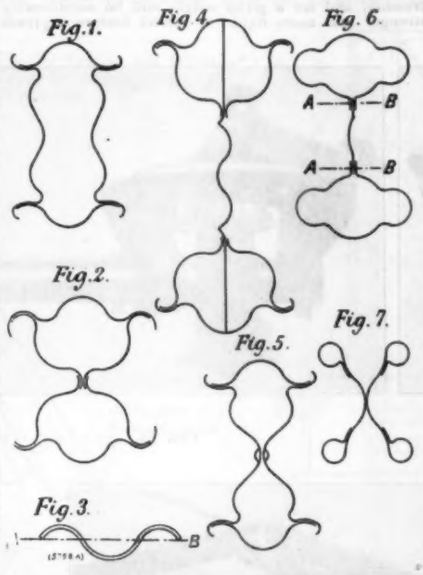
One process of manufacture is therefore by cold-rolling and "blueing" simple carbon steels. The process of rolling develops a grain in the material which cannot be removed even by complete annealing; steel strip is therefore unsuitable for bending or rolling into sharp angles and all strip steel designs should be formed of easy and continuous curves or corrugations. This is a second reason for longitudinal corrugations in design. A second process of manufacturing steel strip is by continuous quenching and annealing low and medium carbon steel strip. The response to this form of heat treatment is very much greater in thin strip than in ordinary sections. There are several modifications of this process. In one process the steel strip passes continuously through a furnace and the red hot strip is quenched by running through an oil bath. The quenched strip then runs through a lead bath and is tempered. In another process it is quenched by running between cast-iron or steel dies through which water is circulating, and is afterwards tempered in a gas furnace. In both the oil-quenching and lead-tempering process and the die-hardening and gas-tempering process care must be taken to cool the strip after being tempered before winding on a coil, otherwise the heat accumulates, and the strength and ductility of the strip at different ends of the coil varies considerably. Some of the best results have been obtained with rejected corset steel. A coil of steel containing about 0·32 per cent. carbon, oil quenched, hardened outright and tempered at 200 deg. C., had a strength of 115 tons per square inch with quite moderately good ductility, while after tempering at 250 deg. the strength was 110 tons per square inch, the yield 90 tons per square inch, and the ductility was sufficient when bent along the grain to enable it to be rolled into a standard corrugated flange. Further tempering of this same strip at 450 deg. C. reduced the strength to about 70 tons ultimate and 65 tons yield, and induced sufficient ductility in the material to enable it to be flattened on itself either way of the grain, so that this metal was quite capable of withstanding being pressed into ribs. The effects of cold-rolling, blueing, quenching and tempering similar steels to the above is set forth in an interesting monograph, Appendix I, by Mr. G. Glenn, contributed by Messrs. Arthur Lee and Sons, Limited. The third process, which has yielded excellent results, has been developed by Messrs. Kayser, Ellison and Co., Limited. This process consists in hardening and tempering, by a special process, alloy steel strip. The resulting product is scoured by a special process and can be welded, punched, rolled and bent longitudinally

* Paper read before the Royal Aëronautical Society, on May 14, 1919.

and laterally without further heat treatment. This steel should be tempered either below 150 deg. C. or above 450 deg. C. if durability and capacity to resist shock and vibration are required. This remarkable phenomenon is set forth in the interesting monograph, Appendix II, by Mr. Henshaw, of Kayser, Ellison. Between these temperatures the Izod impact test gives a low figure. Further properties of this type of steel are set forth in Mr. Mackinder's monograph, Appendix III. It is a pleasure to pay a tribute to the patriotic way in which Mr. Kayser, of Kayser, Ellison and Co., Limited, together with the co-operating firms of Arthur Lee and Co., Limited, and the Effingham Steel Company, and other manufacturers of Sheffield and district, have tackled and solved successfully the problem of the evolution of metal strip suitable for aircraft construction. The strength of metal constructions appears to be governed more by the yield-point than by the ultimate strength, hence attention should be paid to obtaining a good yield-point. Straight steel strip can now be obtained up to 5 in. wide, having yield-points of 100 tons, 80 tons, 60 tons or 40 tons. In ordering strip, care should be taken to order the exact width required, since the process of splitting the strip invariably gives it a curve which can only be corrected by additional heat treatment.

The second material available for metal construction is duralumin. This has many advantages over steel and a few disadvantages. Duralumin being three times lighter than steel, it follows that the various members may be, weight for weight, three times thicker than steel members. Hence the difficulty in overcoming local failure due to local flexure is greatly reduced. Nevertheless, the perfection of a design can only be discovered by constructing it in steel, and it is thought that duralumin designs will be improved by adopting the principles which have proved to be the only feasible ones in steel construction. A prejudice appears to exist in certain quarters against duralumin owing to the fear of corrosion. It should be stated that duralumin, unlike aluminium, is not acted upon by sea water, or affected by atmospheric influences, and experience in connection with airship work shows that duralumin, if properly varnished, is not affected by corrosion under ordinary conditions of service. Nearly every case of corrosion so far experienced in actual practice has been traced back to incorrect heat treatment, or to cold working after heat treatment. The heat treatment of duralumin instead of being a disadvantage, as is often supposed, is in actual point of fact of the greatest assistance in the practical working of the metal. This heat treatment is carried out by placing the member to be treated in a bath containing a mixture of potassium and sodium nitrates heated to a temperature of 480 deg. C. In practice there is a fairly wide margin of temperature so long as 500 deg. C. is not exceeded, in which case there is danger of the metal being burnt and reduced to aluminium. The parts should be left in the bath long enough to be heated uniformly to the temperature of the bath, the actual times allowed being 5 minutes in the case of small units up to several hours in the case of 3-in. bar. There is no danger in leaving it in the bath too long, providing the actual temperature of 500 deg. is not exceeded. At the end of this time the article is removed from the bath and quenched out in water or non-acid oil. Immediately after heat treatment the metal is found to be in a very soft and plastic condition, and it may be pressed, forged, bent to the smallest radius, or in the case of drawn sections which have warped with the quenching, straightened without any fear of damaging the metal. The metal now commences of itself to harden up, and in about an hour's time has reached about 26 tons tensile strength, with an elongation of about 15 per cent. This process of hardening continues for a very long period, the strength slightly increasing at the expense of the elongation. Heating duralumin to 300 deg. C. and then quenching out, anneals the metal, and it can then be worked in any way desired. In order to give it back its strength it is necessary to heat treat it at 480 deg. C., as explained above. In practice it is usual to anneal any duralumin part if a number of operations have to be performed, and on the other hand, to heat treat before final operation, if this is not of too prolonged a nature, taking advantage of its abnormal condition immediately after heat treatment.

An actual example of the value of this property of duralumin in slowly hardening up after heat treatment occurs when duralumin is used for rivets. If an attempt were made to rivet these up in the ordinary hard condition they would crack badly. By heat treating them, however, and using them immediately after this, a perfect job may be made while they are soft, and within a very short time afterwards they have hardened up to their full strength. If duralumin in the ordinary hard condition is bent to a small radius, there is, as would be expected, a probability of incipient cracks developing on the surface of the metal at the bend. These cracks are the places where the corrosion begins. If the metal was properly heat treated before such bending, no injury would be caused to the surface of the metal, and no trouble would be experienced from corrosion. Nearly the whole of the prejudice against the use of duralumin is due to ignorance as to its properties with and without heat treatment. Sections cannot conveniently be drawn thicker than 0·2 in. Above this thickness the sections are extruded. It is advisable to use only solid-drawn sections for constructional purposes, and designs should accordingly be modified to meet the limitations in the material.



Having now described some of the properties of the materials available for metal construction it remains to describe methods of utilising these materials in an efficient and practical way. The structure of an aeroplane may be divided into two main portions: (a) The vital members, such as spars, struts, longerons and lift wires, and (b) the members giving form or bulk, such as ribs, ailerons, elevators, &c. The latter members are not stressed to the maximum limit in the same way as the vital members, and present no great difficulty in competing with wood. Thus, metal ailerons have been made and tested which were 40 per cent. lighter and 60 per cent. stronger than the wooden ailerons they were designed to replace. Improvements in design are to be looked for only in increasing the cheapness of manufacture. With regard to the vital members the problem is far different, and here all our ingenuity and knowledge are required. Metal designs are required for three main types of machine: (a) Small machines up to 3,000 lbs.; (b) intermediate machines from 10,000 lbs. to 15,000 lbs.; and (c) large machines of from 30,000 lbs. to 200,000 lbs. The largest members in a machine are the wing spars, and these present the greatest difficulties in construction—the next largest members are the struts. As it is impossible to deal with the whole vast problem of metal construction in one paper it is proposed to limit the description to these members for the above types.

A section of the Rudge spar, developed from designs courteously placed at the firm's disposal by Lieutenant-Commander H. Wylie, and suitable for the Avro machine, is shown in Fig. 1. In this spar an effective strength of 80 tons per square inch is utilised in the steel. To meet the weight requirements the thickness of the flange strip is reduced to 1 per cent. of its width, while the thickness of the web strip is reduced to ¼ per cent. of its width. To prevent local failure the strips have been formed into longitudinal corrugations, the radius of each corrugation being from 30 to 100 times the thickness of the metal, a smaller radius being used when the highest compressive stresses are to be withstood. These corrugations are so effective that the Rudge spar shown has developed a compressive stress of 83 tons per square inch in the flange, while the webs have remained intact under a shear stress of about 30 tons per square inch. When tested at the Royal Aircraft Establishment it was found that this spar is 10 per cent. lighter and 5 per cent. stronger than the wooden spar it was designed to replace. Fig. 2 shows a modification of the Rudge spar for intermediate type machines. The first step is to deepen the central corrugations in the webs so that they meet together, thus forming the section into two tubular units. Each web is formed of two pieces joined together at the neutral line. This is necessary in view of the limited width of strip available. The free ends of the flange are turned inwards so that the maximum stress is not developed at the free edge. This considerably increases the strength of the flange. The best disposition of the free ends of the strip constitutes one of the problems of metal construction. The solution lies in placing the free ends in a position where they will be stressed as little as possible. Failing this they must be locally supported or strengthened if the full strength of the metal is to be developed without local failure. The Huns solved this difficulty very well with their Zeppelin bracing. They stamped the diagonal bracing members to the section shown in Fig. 3. Thus, the free ends A B were on the neutral line and were not stressed when the member was in compression as a strut. Fig. 4 shows a modification of the Rudge spar for a larger machine of the intermediate type, or a small machine of the large type. With this type of spar the metal must be increased in thickness to retain sufficient stability. These derived sections are obviously weak about the waist, and support must be given by cross frames, or formers, which occur suitably at each rib. With the addition of these frames the section is made stiff in all directions, even when the strip composing it is of extreme thinness relative to its width. The flanges are supported in the middle by extending the web into contact with the inner surface. Fig. 5 shows a modification of Fig. 1. The depth of the spar may be readily altered by varying the depth of the central corrugations of the webs, the minimum depth being obtained where the corrugations meet in the centre. In the event of the corrugations

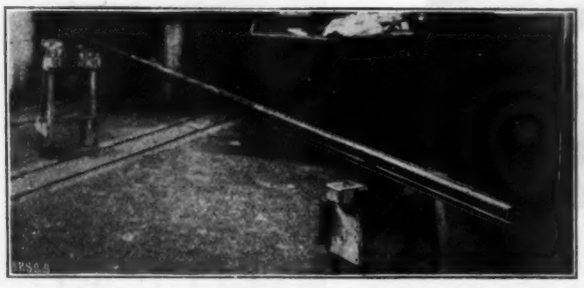


FIG. 8.

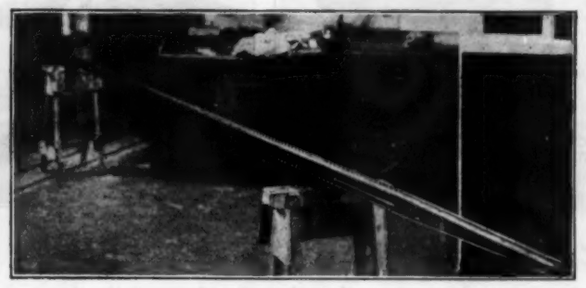


FIG. 9.

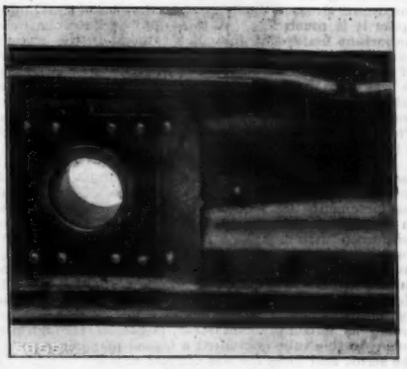
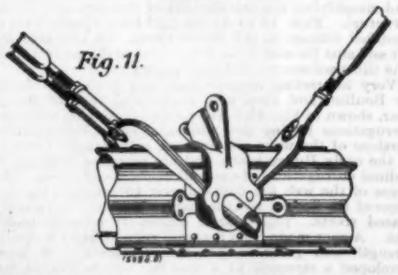


FIG. 10.



not meeting, as in Fig. 5, it is necessary to join the webs together at intervals by a cross-tubular member riveted to each. The above designs are adapted to be riveted together either by hand or by machine.

Several designs have been adopted to utilise spot or strip welding—this dispenses with the difficult, and, at present, somewhat expensive, process of riveting. One such design, known as the Dunlop single spar, is shown in Fig. 6. Three coils of strip of the required width are mounted on the rolling machine. After passing through the banks of rolls each strip emerges of the required shape and passes through guides which hold the strips while they are passed between two pairs of copper discs at A and B, which are the terminals of an electric circuit. A powerful current then passes from one disc to the other through the steel strip. The resistance offered by the strip to the passage of this current is sufficient to raise the strip to a melting temperature. After leaving the discs the ends of the strip are firmly incorporated together at the points A B. The spar emerges complete from the machine at the rate of 9 feet per minute. This spar is almost the same in section as Fig. 4, except that each tubular unit is rolled from one strip instead of being built up from three strips. This feature is advantageous in many ways, but limits the size of the tubular unit to about 2 ins. wide on account of the difficulty of obtaining and working up high tensile strips wider than about 6 ins. One great advantage of the Dunlop type of boom is the absence of the projecting ledges provided on the previous spars for connecting the component strips together. These ledges are liable to buckle when high longitudinal compression stresses are developed in them, even if they be curved throughout and rolled round on the edges as shown in the illustrations.

Fig. 7 illustrates a section known as the double Dunlop spar. The edges of two strips are rolled into tubes and strip welded, the intermediate portions of the strip being longitudinally corrugated. The formed strips are placed back to back and joined together by spot welding. This spar is in effect two bicycle rims placed back to back and connected at the centre. Similarly to the Dunlop single spar it requires to be supported by frames, or formers, at intervals to prevent the individual booms from bending as struts transversely to the web. The formers may conveniently be introduced at each rib. It has been found from tests that the distance between frames, or formers, should not exceed 60 times the radius of gyration of the booms. Hence, for this spar, the booms require to be about 1 in. wide. This spar can be made as light as 0·5 lb. per foot run. and develops the same strength as a wooden spar of from 0·65 lbs. to 0·85 lbs. per foot run. This type of construction is the cheapest and simplest yet developed. Results of a test on one of these spars in simple bending and shear will be found in Table II of Appendix IV.

In the spar designs shown the strips run continuously throughout, no holes being cut to lighten the sections. This continuity is a feature, and has great advantages, for it has been found in tests that destroying the continuity weakens the spar considerably. Lightness can be obtained with less sacrifice of strength by reducing the thickness and increasing the curvature of sections. From experience it would appear that spars with continuous webs can be made as light as with any system of trussing, and for a given weight will be considerably stronger and more rigid. A second feature in these designs is the absence of rivets and other means of connection along the lines of maximum stress. In the Rudge spar, for instance, the maximum possible tensile stress along the line of rivets is about 85 per cent. of the maximum stress in the flange. In the case of the Dunlop spars it is much less. A third and perhaps the most important feature is that all the metal in the section, except the cross-frames of the ribs, is taking its share of the load, so that even if the average stress over the area is less than is developed in the longitudinal parts of lattice spars, the absence of bracing pieces more than compensates for the lower failing stress of the flanges. Photographs of a Rudge spar are reproduced in Figs. 8 to 10.

Another problem of metal construction, presenting in fact almost as much difficulty as the actual design, is the attachment and design of fittings. Fittings and reinforcements are required whenever a load is applied in order to distribute that load. Thus, spars should be reinforced with boxes at the inner ends to distribute local bending moment due to inequalities of end loading. In addition, all fittings should preferably be attached to the neutral line. Fig. 11 shows a method of doing this for the Rudge spar. The webs are reinforced by plates which carry a short tube. Another tube, acting as a compression strut, is passed through the hole; to this tube is pivoted a forked member carrying the strut, and links for the lift and anti-lift wires. By this means all the forces cut one another on the neutral line of the spar, thus avoiding offset bending moments and simplifying the calculations of the strength of this structure. Figs. 12 to 14 are half-tone illustrations of modified fittings of the Rudge spars. In this case the lift and anti-lift wire links are pivoted to the central tube. The illustrations are self-explanatory.

Very interesting experiments have been carried out by Boulton and Paul with a modified type of Rudge spar, shown in Fig. 15. The flange is provided with two corrugations having flat horizontal edges. The centre portions of the webs are stamped with flanged holes as in the early Rudge spars, and are provided with longitudinal corrugations above and below these holes. The edges of the web are doubled over to embrace the flat edges of the flanges and the spar is completed by suitably placed rivets. This spar is extremely efficient under test. A spar made from material whose ultimate tensile strength was given by the manufacturers as 40 tons, developed a stress of 43·5 tons per square inch in the flanges before failure. It is claimed that this spar is 12 per cent. lighter than a spruce spar and will sustain 70 per cent. increased bending moment. The first specimens were rolled from 40-ton steel 0·018 in. thick. Flanges of steel with higher tensile strength are now used, and the ultimate strength of the flanges is developed simultaneously with the ultimate shear stress of the webs Fig. 16 shows an early specimen in shackles, taken after testing to destruction. The flange of this specimen is provided with a single shallow corrugation and failed before the full strength of the specimen had been developed. The dent in the flange shows where the spar failed. Fig. 17 is reproduced from a photograph of a complete pair of wings provided with Boulton and Paul spars.

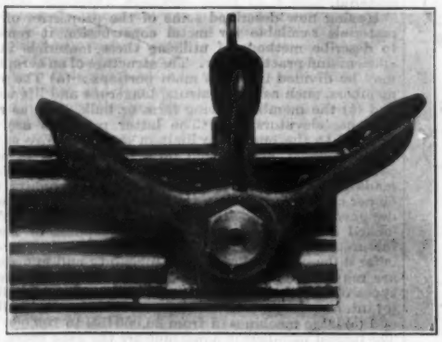


Fig. 12.

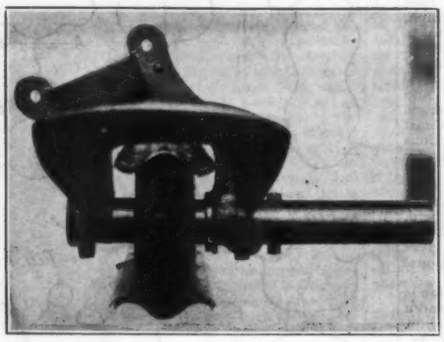


Fig. 13.

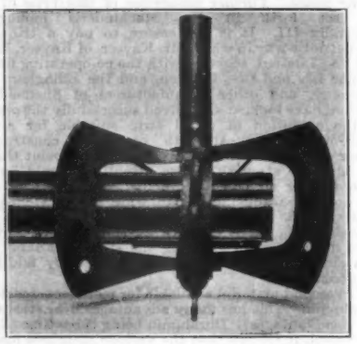


Fig. 14.

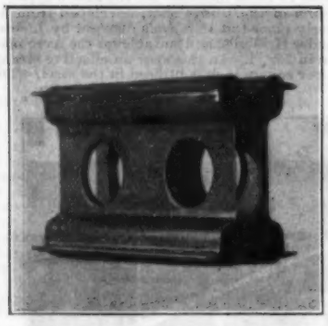


Fig. 15.

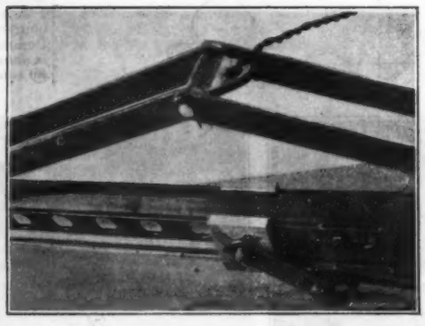


Fig. 16.

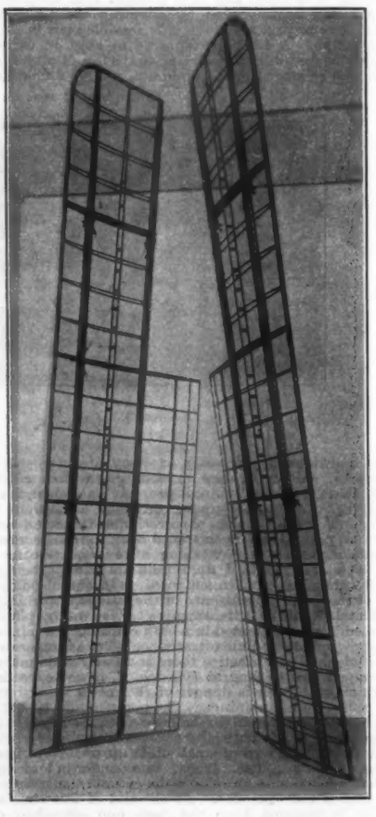


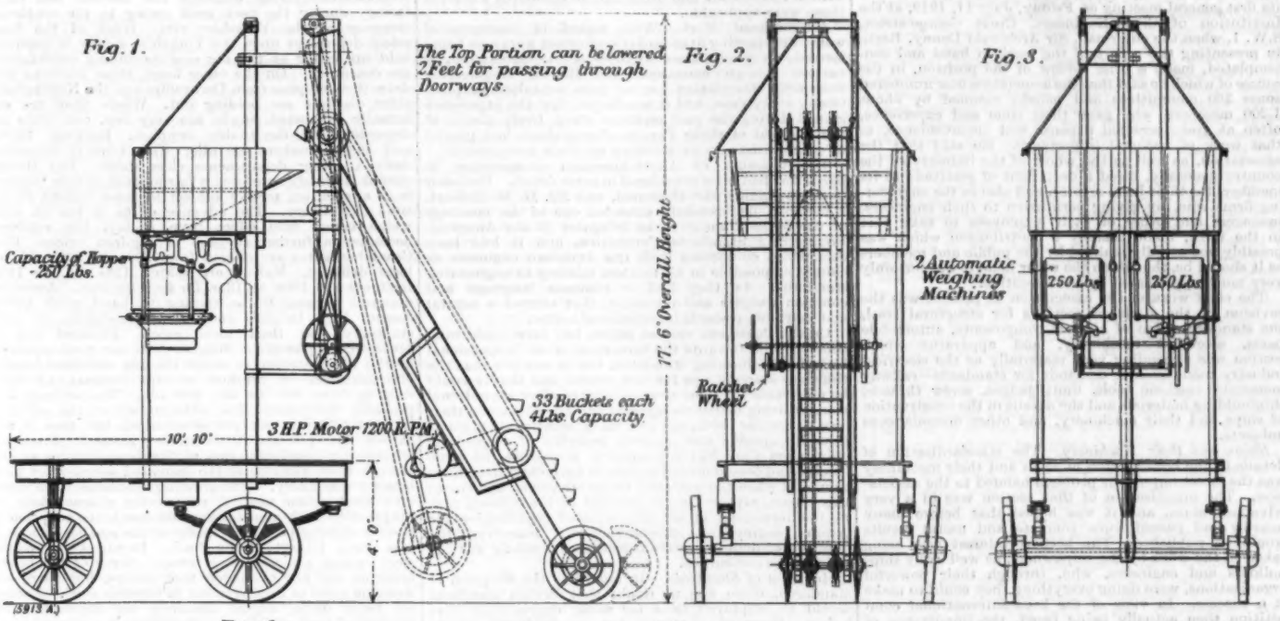
Fig. 17.

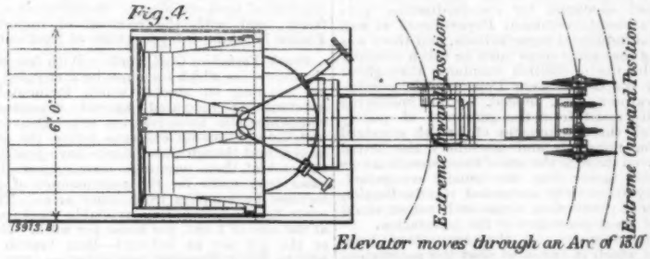
(To be continued.)

PATENTS AND TRADE MARK CONGRESS AT BRUSSELS.—An International Congress of Allies and Neutrals to discuss the question of patents and trade marks is being organised to take place at Brussels in September, says *The Board of Trade Journal*. The arrangements are being made by certain Belgian societies—the Chamber for the Protection of Inventions and Mechanical Arts (Technical and Scientific Committee), the Mechanical Arts Section of the Brussels Chamber of Commerce, and the International Committee of the Federation of the Associations of Invention and Mechanical Arts of Allied and neutral countries. These have nominated a commission to organise meetings early in September. The Congress, like the Third International Congress of 1910, will deal chiefly with the protection and development of industrial property in various countries.

PORTABLE GRAIN ELEVATOR.

CONSTRUCTED BY MESSRS. BROWN, DUNCAN AND CO., ENGINEERS, BOOTLE, LIVERPOOL.





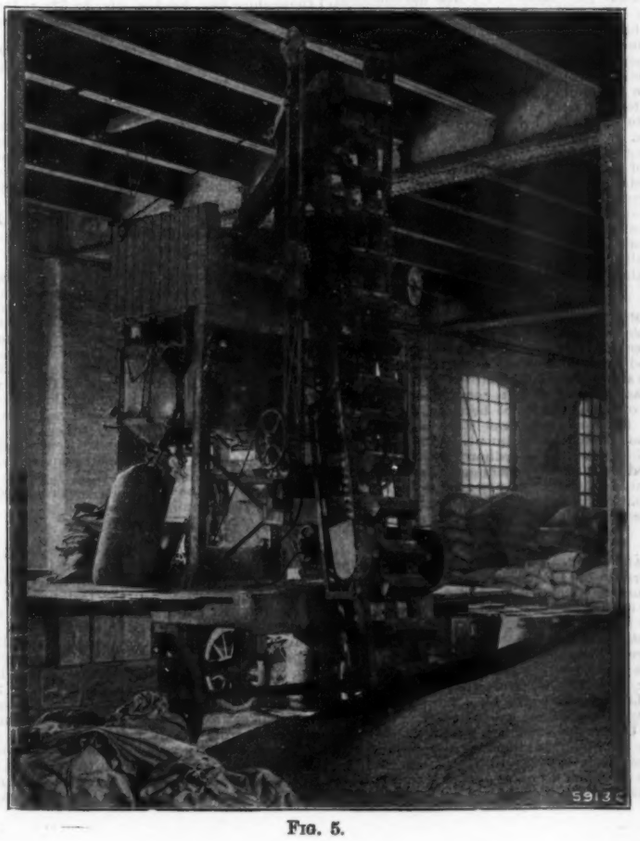


FIG. 5.

AN interesting portable grain elevator is illustrated in Figs. 1 to 5, on this page. It is intended for lifting grain from the floor, weighing it and loading it into sacks. The machine can be moved about on its own wheels and should be very useful for dealing with grain in warehouses and transit sheds. It is possible to remove grain from 60 sq. ft. of floor space with the elevator in one position. The machine is manufactured by Messrs. Brown, Duncan and Co., of Canal Iron Works, Hawthorne-road, Bootle, Liverpool.

The general construction of the appliance is well shown in the figures. It consists of a hopper supported by three columns from a wagon-type body. The hopper is provided with two automatic weighing machines suitable for filling sacks. The grain is elevated by buckets mounted on a chain revolving on sprockets, and the elevator leg is arranged so that it automatically runs out as the grain is removed from the locality of the buckets. A winch is provided to haul the leg in again when it has reached its extreme outward position. The leg and frame carrying it can then be rotated around the hopper to a new position, so that another portion of the floor may be cleared without moving the machine. The filled sacks may be loaded directly on to wagons from the body of the machine, as will be clear from Fig. 5. Two wagons may be loaded at a time. The elevator is driven by a 3-h.p. variable-speed motor, which drives through a 6 to 1 reduction gearing, and from thence by a "Ewarts" detachable chain to a countershaft mounted on the elevator leg. From this countershaft a drive is taken to the top shaft carrying the elevator chain sprockets. The total reduction is 14 to 1. The total weight of the whole arrangement is 3 tons, and it can be easily moved by a working gang of six men.

The first machine built was supplied to Messrs. T. and W. Harrison, of Liverpool, and though it was only rated at 15 tons per hour was found capable of exceeding this quantity with one weighing machine only in action. When using both machines it was capable of handling nearly 40 tons an hour. To test the accuracy of the weighing, five 250-lb. filled sacks out of 50 were selected, and it was found that the maximum variation from dead accuracy was only 1 oz.

CHIEF CONSTRUCTOR, SHEERNESS DOCKYARD.—Mr. John Rogers, O.B.E., R.C.N.C., Assistant Director of Materials at the Admiralty, has been appointed as Chief Constructor at H.M. Dockyard, Sheerness. Mr. Rogers has been attached to the Admiralty for the past seven years, principally in connection with the inspection and supplies of steel and iron materials for warship building, and on the formation of the Materials and Priority Department, in June, 1917, was selected to assist Sir Robert (then Colonel) Horne, in connection with the contro of steel. He was appointed to this position on account of his wide experience as a naval shipbuilder, his practical knowledge of the manufacture of iron and steel, and his acquaintance with all the leading steel works of the country. His service in the new department proved invaluable in the organisation and administration of the steel control.

BRITISH ENGINEERING STANDARDS ASSOCIATION.

The British Engineering Standards Association held its first general meeting on Friday, July 11, 1919, at the Institution of Civil Engineers, Great George-street, S.W. 1, when the chairman, Sir Archibald Denny, Bart., in presenting the report of the work in hand and contemplated, made a brief review of the position, in the course of which he said that the association now numbered some 360 committees and panels, manned by about 1,200 members, who gave their time and experience, often at great personal expense and inconvenience, to that work of national importance. He said that the association, as well as the whole of the industry of the country generally, owed a deep debt of gratitude to its members for their loyal service, and also to the engineering firms who, by giving permission to their engineers, managers and other of their employees to take part in the work, made thereby a contribution which was possibly not as fully realised by the public and members as it should be, though on the other hand it was certainly very much appreciated by the executive.

The chief work of the association at present was the revision of the standard sections for structural steel, the standardisation of aircraft components, automobile parts, electrical machinery, and apparatus—which section was expanding very materially as the electrical industry made greater demands for standards—railway materials, machine tools, limit gauges, screw threads, shipbuilding materials and the details in the construction of ships and their machinery, and other miscellaneous subjects.

Ships and their Machinery.—The standardisation of details in the construction of ships and their machinery was the latest important problem handed to the association. The organisation of that section was in a very advanced state, and it was hoped that before many months had passed some concrete and useful results would be published. The keenest interest was being taken in the work by the shipowners, as well as by shipbuilders and engineers, who, through their powerful organisations, were doing everything they could to make it a success. In view of the keen international competition then actually being faced, the importance of pushing standardisation without loss of time would be apparent.

Aircraft Materials.—The successful operations of the association in connection with the work carried out for the Ministry of Munitions (Department of Aircraft Production), in the standardisation of aircraft materials and parts was familiar to many, that part of the work for the last year had been more than great, it had been colossal. That section was now being put on to a peace basis, and, through the Air Ministry, the Treasury had agreed to make a substantial grant on the same lines as during the war, in order that that work might be prosecuted to its fullest extent.

Overseas Committees.—The association was establishing, in a number of foreign countries and Overseas Dominions, local Standards Committees of British engineers and traders in order to disseminate British standards and so assist British manufacturers in developing their foreign trade. A short report had been issued to subscribers to that particular section of the association's activities, as well as to a large number of interested people and trade organisations, in order that they might have some details before them of the actual progress made, and consider to what extent they could still further associate themselves with the scheme and promote its success. An extract from the report read: "The whole overseas scheme of the association may indeed, from one aspect, be looked upon as a means of advertising British engineering products, and there is no doubt that were even a small proportion of the sum annually spent by manufacturers upon advertisements allocated as subscriptions towards carrying on of this scheme, it would be greatly to the advantage of British trade generally."

So far as the financial aspect of the overseas scheme was concerned, no provision had yet been made for recurring expenditure, and that would have to be taken seriously into account in the near future, if the Local Committees were to be in a position to assist the industry to the fullest extent. The British Chambers of Commerce were now co-operating in the work, which would have a material effect on the financial side, as well as help the work forward in every way, and it was earnestly hoped that trade organisations would take a direct interest in those Local Committees and assist the association in attaining the object in view, especially as it was the intention to invite the Governments of the different countries to nominate technical officers from their large spending departments to sit on the committees.

The association had translated a number of its more important specifications into Spanish, Portuguese, Italian and French, and distributed them in considerable quantities to the various Local Committees.

The committees had been formed through the assistance of the Foreign Office and the Overseas Department of the Board of Trade, who had placed the services of the Consular Officers and Commercial Attachés, and also Board of Trade Commissioners, at the disposal of the association, and those gentlemen had been, and were, giving valuable assistance. It had been a very striking development on the part of the Government, who had subscribed 10,000*l.* in support of the work, industry generally having subscribed some 14,000*l.*

So far as the Dominions were concerned, the South African Engineering Standards Committee had agreed to act as the representative committee of the association in the Dominion. The Canadian Committee, recently incorporated under Dominion Charter, was acting as the association's representative in Canada, and would take every opportunity of familiarising Canadian engineers with British standards. In Australia, an Engineering Standards Committee was on the point of formation, and there was every hope and indication of Australia's working in close co-operation with the British Association and using British standards wherever those were applicable.

International Work.—With regard to international work, Engineering Standards Committees were now being formed, on similar lines to those of the association, in various foreign countries, the British Engineering Standards Association having been consulted in practically every case, and it was hoped that the experience gained during the past eighteen years, freely placed at the disposal of these Foreign Committees, had proved of some assistance in building up their constitution.

The question of Anglo-American co-operation in particular had been considered in some detail. Professor Comfort Adams, the chairman, and Mr. H. M. Hobart, a member, had recently attended one of the meetings of the Main Committee as delegates of the American Engineering Standards Committee, and it had been decided to co-operate with the American engineers as closely as possible in all matters relating to engineering standards. As they had a common language and common weights and measures, that seemed a natural and easy step towards international action.

On the Continent various efforts had been made from time to time towards the formation of an international body for engineering standards, but it was felt that the time was scarcely ripe for such action, and that it would be preferable for some time to come to allow the national standardising bodies to organise and co-ordinate in their own particular fields, and to form international organisations for specific and separate branches of engineering only when they had advanced to somewhat the same level as had been done in England in national standardisation, and when the necessity for international agreement was shown, rather than to attempt such a colossal task as the formation of an international organisation for general engineering standardisation; moreover, the question of detailed international specifications was full of immense difficulties.

Adoption of Standards.—In regard to the adoption of standards, there was no doubt that British standards would be employed to a far wider degree than ever before. Constant demands for standardisation were coming from various Government Departments as well as from powerful industrial organisations, and there was a general feeling that some steps must be taken officially to encourage the use of British standards throughout the country by the Government Departments, municipalities, corporations, and, indeed, by all specifying engineers. Quite apart from the guarantee of quality obtained through the employment of British standard specifications for materials and machinery the actual value of time saved through the use of those specifications was a far greater factor than was usually recognised, and, seeing how intimately connected standardisation was with national production, some such action could not fail to be of great assistance to the association.

Finance.—The accounts of the association were presented, from which it appeared that the association was still somewhat hampered in its free development, due to the fact that sufficient funds were not yet at its disposal to enable it to be generously staffed and housed. The industry, however, was increasingly recognising the utility and importance of standardisation to the nation's production, and doubtless that would gradually be remedied. The accounts were adopted and Messrs. Deloitte, Plender, Griffiths and Co. were re-elected as auditors, a vote of thanks being accorded to them for their past work.

An interesting letter from Mr. D. N. Dunlop, director and secretary of the British Electrical and Allied Manufacturers' Association, dealing with the question of more efficient arrangements for collecting funds, was intimated, and the chairman stated that the Main Committee would take the matter into serious consideration in the early autumn. A vote of thanks having been passed to the chairman and also to the secretary and his staff for their efficient work, the proceedings terminated.

The Leparmentier Double Hull Vessel.—An article in *Le Génié Civil* gives an illustrated description of the Leparmentier type of vessel, in which two hulls are so connected as to present the aspect of an ordinary ship. The hulls are cylindrical, separated into watertight compartments and connected by a common construction which permits of using the space between the hulls as water ballast. Some of these vessels are being built in America for the French Government. Comparing the Leparmentier design with the ordinary type of ship, it has been claimed that, for equal tonnage, the new design uses 30 per cent. less weight of plates and angles than an ordinary ship. The time required to build is shortened, and the cost per ton of the Leparmentier is about 40 per cent. cheaper.

Aeronautical Engineering.—The East London College (University of London), at which important aeronautical work has been conducted during the war, is arranging for two courses of instruction in aeronautics, commencing in September next. The first course is of one year's duration, and is suitable for those who have some knowledge of engineering and science subjects. The second is a three years' course in engineering and aeronautics for the B.Sc. (Engineering) Degree of the University of London, and will be conducted by Mr. N. A. V. Piercy, B.Sc., a recognised teacher of Aeronautics of the University. Experimental wind-tunnel work will form an important part of the course, and facilities for research will be available. Particulars of these courses may be had on application to Mr. E. J. Wignall, Registrar of the College.

NOTES FROM SOUTH YORKSHIRE.

From our own Correspondent.

Sheffield, Wednesday.

Iron and Steel.—The position in most of the iron and steel manufacturing concerns has become less satisfactory during the past week owing to the continued stoppage at the Yorkshire pits. Work of the firms solely dependent upon the Yorkshire supply is generally held up so far as the big coal-consuming departments are concerned. On the other hand, those concerns who draw their supplies from Derbyshire and the Nottinghamshire districts are holding out. Where they are not actually exhausted, stocks are very low, and firms are dependent on day-to-day supplies. Between 20,000 and 30,000 workers are idle. This total is increasing daily as other departments close down. But though output is greatly restricted a fair amount of new business is in circulation, mostly subject to rates current at the time of delivery. The advance of 6*s.* a ton on coal, which comes into effect from to-day, has rendered necessary a further revision of pig-iron prices. East Coast hematites are offered from 200*s.* to 202*s.* 6*d.* for local delivery. Makers are asking 158*s.* 9*d.* to 160*s.* for forge and 160*s.* to 164*s.* for foundry iron. American material appears to be coming to hand more freely, despite high freights and other drawbacks, at substantially less than local rates. Finished iron is rather more plentiful. Belgian bars are now available at 17*l.* 10*s.* Antwerp, or about 19*l.* 15*s.* delivered locally. Manufacturers of finished articles forecast advances ranging from 30*s.* to 50*s.* per ton. The average will probably not exceed 35*s.* The extent of the advance in steel billets is not yet determined, but that it will exceed 20*s.* per ton is taken for granted. From an engineering standpoint one of the best features of the current trade position is the increased demand for tool-making machinery. File-grinding machines have come into much wider use. A noteworthy characteristic in conjunction with machine installations is the adoption of electric driving power by many of the smaller concerns, who have hitherto hung back. Inquiries for motor steel suggest a more active future. Some of the heavy branches are not overladen with orders, but there are welcome signs of improvement in crucible steel. Except for twist drills, export demands for engineers' and mechanics' tools are heavy. Scandinavia is buying more freely, and with the removal of import embargoes, France is taking a bigger share of local output.

South Yorkshire Coal Trade.—With few exceptions, all the industries which have not been crippled by the strike are running on stocks, which fortunately had been substantially increased against emergency. Railway companies still have reserves left. Deliveries to power and light-producing concerns before the stoppage were heavy, and though these plants have practically reached the end of their resources, arrangements have in most cases been made for the maintenance of public utility services by supplies from other areas. The local coal controller is distributing available stocks of house coal at the rate of 1 cwt. per house per week. Nominal prices at the pit are as follows:—Best branch handpicked, 33*s.* to 34*s.*; Barnsley best silkstone, 33*s.* to 33*s.* 6*d.*; Derbyshire best brights, 31*s.* to 32*s.*; Derbyshire house coal, 28*s.* 6*d.* to 29*s.*; Derbyshire best large nuts, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire small nuts, 27*s.* 6*d.* to 28*s.* 6*d.*; Yorkshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; best slacks, 24*s.* to 25*s.*; nutty, 23*s.* to 24*s.*; smalls, 19*s.* to 20*s.*

Commercial Travellers in Switzerland.—The following figures furnished to the Federation of British Industries by a well-known man of business in Switzerland, as to the number of commercial travellers there in 1913, are significant as showing the leeway which this country has to make up in its efforts to extend British trade in Switzerland: Germany, 4,797; France, 1,513; Italy, 276; England, 81.

The Controller-General of Merchant Shipbuilding.—Lord Pirrie, Controller-General of Merchant Shipbuilding, has been able to demobilise his department to such an extent that after consultation with the Shipping Controller, he decided to vacate his offices in the Ministry of Shipping, Great George-street, Westminster, S.W. 1, yesterday, and to transfer to his own offices at 1a, Cockspur-street, S.W. 1, where he will keep in touch with the Shipping Controller and his own staff, and be available to deal with any outstanding questions. Communications, other than those of a nature personal to the Controller-General, should continue to be addressed to his department in the Ministry of Shipping, St. James's Park, S.W. 1, where the remainder of the staff of the Controller-General's Department will in future be accommodated.

Cadmium as Substitute for Tin in Solder.—Owing to the enormous demand for tinned food containers and to the general trade condition, a scarcity of tin arose in the United States in the last part of the war, and cadmium was tried as a substitute for tin in solders. According to the Press Bulletin No. 407 of the United States Geological Survey, dated May, 1919, sufficient experience as to the advisability of this substitution had not yet been obtained by the time when, with the armistice, the situation changed. Some 20,000 tons of tin are annually wanted in the United States for soldering, and it is estimated that 600 tons of cadmium could be recovered from the dust of zinc smelters, instead of the 100 tons actually recovered. Germany is supposed to have resorted to cadmium in the place of tin very early in the war, and it is considered that, as regards solder, 1 lb. of cadmium can replace from 3 lb. to 5 lb. of tin.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The decision of the Cleveland ironmasters not to advance for the present the fixed maximum prices of pig-iron to cover increased cost of output in consequence of dearer fuel created some surprise, much relief, and considerable satisfaction. The makers, in coming to this decision, doubtless, had in view the position of the export trade. Foreign business has of late been practically at a standstill, and consumers in this country have become importers to some extent. With Luxemburg iron being actually delivered in England, and America snatching our trade in several markets abroad, it seems highly desirable that the Cleveland iron trade should not be further handicapped by increased prices. Home business is only quiet, but with the position stabilised once more improvement may be looked for. Output of foundry iron is very inadequate, but forge, mottled, and white qualities were quite plentiful. For home consumption, No. 3 Cleveland pig-iron and No. 4 foundry are 160*s.*, No. 1 is 164*s.* and No. 4 forge 157*s.*, whilst export rates are 5*s.* above these quotations.

Hematite Iron.—The decision not to advance quotations applies also to hematite iron. In this branch the need for change seemed much less pressing than was the case with Cleveland pig-iron, for there has been a rise of 10*s.* in hematite whilst Cleveland pig-iron prices have been stationary, in addition to which hematite makers have benefited by a fall in ore consequent upon the easier freight market. There is little hematite available for early sale. It is reported that stocks of East Coast hematite held in Italy are being sold in that country at considerably below the prices at which purchases could be made here. Nos. 1, 2 and 3 are 200*s.* and No. 1 is 202*s.* 6*d.* for home use, and export quotations are 205*s.* and 207*s.* 6*d.* respectively.

Foreign Ore.—Little new is ascertainable as regards foreign ore. Business just now is very quiet, but, though there is a lull in buying, consumers holding off in anticipation of further fall in values, it is gratifying to find that July imports are more than double those of June. The freight market shows further tendency to ease, steamers Bilbao-Middlesbrough being obtainable at 26*s.* and less, so that best rubio ore may be given as in the neighbourhood of 54*s.* 6*d.* c.i.f. Tees.

Coke.—Recently advanced coke prices are well maintained, and there is a good deal of business passing. Transactions on home account are reported substantial, but foreign trade is irregular and on only a very limited scale. Local consumption is heavy, and average blast-furnace quality is realising 48*s.* at the ovens; whilst low phosphorus sort makes 49*s.* 6*d.* at the ovens. For shipment to neutrals foundry coke is quoted 70*s.* to 75*s.* f.o.b.

Manufactured Iron and Steel.—Marked quietness characterises the finished iron and steel industries. A feeling of uncertainty prevails, and traders are not at all disposed to operate. Manufactured iron prices have been advanced 30*s.*, but no announcement is made with regard to steel quotations. Principal market rates now stand:—Common iron bars, 22*l.*; marked bars, 24*l.* 10*s.*; strip iron, 23*l.* 5*s.*; steel ship, bridge and tank plates, 17*l.* 15*s.*; steel ship angles, 17*l.* 5*s.*; steel joists, 17*l.*; heavy sections of steel rails, 16*l.*: and steel hoops, 23*l.* 5*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Work Resumed.—Throughout the West of Scotland work generally was resumed this week in the steel, iron, coal and engineering trades, but reports show that the start was not quite as satisfactory as it might have been. The prevailing tendency has been for an extended holiday this year, and this is attributed to three things—the excellent weather which has been general in the Clyde area all the month, a plentiful supply of money, and the fact that during the past four years it was necessary to make the annual holiday as short as possible on account of the urgency of the call for munitions of war. Monday next is the day of the peace celebrations in Glasgow and neighbourhood, and it is feared that many of the workers may not resume work until after that day, by which time their holiday will have extended into the third week.

Scotch Steel Trade.—In the Scotch steel trade there is little to report. Repairs have been general, and in some cases these were extensive and very necessary this year owing to the high pressure at which the mills have been running during recent months. The number of orders in hand ensure steady employment for some time, but with the enhanced prices now necessary for the local make of steel, and the keen competition expected from America it is quite impossible to forecast how the second half of this year may go and what may be the result. The price of hematite is now quoted at 10*l.* 10*s.* per ton, net, f.o.b. works, which is an advance of 5*s.* per ton, but which is rather less than what was anticipated. It was not found necessary, however, to raise the price any higher in the meantime, as a reduction had been made in the freight for ore. All prices are practically withdrawn pending the fixing of the new rates consequent upon the 6*s.* advance in the price of coal.

Malleable Iron Trade.—Work in the malleable iron trade was resumed this week, and the bookings before the holidays are sufficient to keep plant running steadily for a bit. With the increased costs prices have been raised by the Associated Makers by 30*s.* a ton. For home consumption, "Crown" bars are now quoted 21*l.* 12*s.* 6*d.* per ton, net, f.o.r., and for export the figure is 22*l.* per ton, net, f.o.b. Glasgow.

Scotch Pig-Iron Trade.—Owing to the holidays there has been nothing doing in pig-iron in the West of Scotland for nearly a fortnight, and in consequence there is none on offer. The scarcity has been very marked for some time back, and there is little immediate prospect of any improvement in this condition. Consumers are all in great need, and the rationing system will again be prevalent as the iron becomes available. A new record price has been touched by foundry iron, which is now quoted over 10*l.* per ton.

Scotch Coal Trade.—The collieries which were off on holiday during the past week have mostly got well under way now, and the general report was that quite a good start had been made. The prices are now all up to the extent of 6*s.* per ton, and the consumers are feeling very sore over this heavy rise. The demand is good for supplies to the gas works and the railways, but commercial concerns are only buying sparingly, and firms who formerly only purchased the highest grade qualities are now contemplating the testing of the possible outcome from some of the lower-priced qualities. In order to maintain their trade as against the foreigner they state that now, more than ever, their business must be most carefully and economically run. The export trade is very quiet indeed.

Clyde Shipbuilding.—The Clyde shipbuilding output for the month of July was very satisfactory, and compares favourably with the same month prior to the war. For last month the figures are 10 vessels totalling 30,592 tons, making the total for the year to date 155 vessels of 295,398 tons, as against 141 vessels of 283,893 tons for the corresponding period of 1914. Most of the launches last month took place in the early part of it, and one noteworthy feature is that neither Greenock nor Port Glasgow launched one vessel during July. Another interesting item is that the Ardrossan Shipbuilding Company launched the first vessel from their new yard, the steamer Hunstanworth, 2,500 tons, for Messrs. Dalgleish, Newcastle. Of the total output of 10 vessels three were to the order of the Government—one destroyer, one steam drifter and one tug. During the month there have been few new contracts placed, but there is a lot of work on hand, estimated at close upon 900,000 tons.

THE LATE MR. H. H. P. POWLES.—We regret to record the decease of Mr. Henry Handley Pridham Powles, who died on the 27th ult., at a nursing home in London, after a few months' illness. He was born at Upper Clapton, Middlesex, on August 4, 1846, and was the youngest son of Thomas Octavus Powles, a member of the Committee of Lloyd's. Mr. Powles was educated partly at private schools and partly at the Ipswich Grammar School. In January, 1864, he was apprenticed to Messrs. E. R. and F. Turner, of St. Peter's Ironworks, Ipswich, and served his time there in the shops and in the drawing office. In 1869 he went as improver and engine fitter to Messrs. Ransomes, Sims and Head, of the Orwell Works, Ipswich. In 1871 he returned to Messrs. Turner's works, and was employed in the drawing office and on the works in various parts of the country. In 1872 he was employed by the same firm as a draughtsman until 1876, when he became head draughtsman. He remained at this works in the above capacity until 1890, when he went to London to act as mechanical engineer to the Electric Standardising and Training Institution, Faraday House, which had just then started in temporary premises in Adam-street, Adelphi. He arranged and fitted up the workshops at the new premises of the above Institution in Charing Cross-road, and remained with this Institution until January, 1898, when he joined Sir Alexander Kennedy's technical staff as assistant, and was put in charge of the drawing office. Mr. Powles remained as an assistant to Sir Alexander Kennedy until January, 1912, and had been until his death retained by Messrs. Kennedy and Donkin for research work and inspections. During 1916 and 1917 he was employed in inspecting constructional work and plant for one of the munition factories. In 1917 and 1918 he did extremely useful work in preparing a bibliography of all works connected with the subject of lubricants and lubrication for the Scientific and Industrial Research Department. The work that he did in this connection was somewhat strenuous for his years, and he perhaps was over-conscientious in completing this work in spite of failing health. He was known by a large body of engineers, especially electrical engineers, who passed through Faraday House when he was there as mechanical engineer. His work for Sir Alexander Kennedy was very highly valued, and his sound judgment and engineering experience will be greatly missed. He was elected an Associate Member of the Institution of Civil Engineers in December, 1880, and a full member of the Institution of Mechanical Engineers in 1891. In 1887 he translated Dr. Friedrich Kick's standard work on flour manufacture. He also translated H. Haeder's book on the steam engine. Mr. Powles was responsible during the last seven or eight years for the revision and enlargement, for Messrs. Crosby Lockwood, of D. K. Clarke's "Mechanical Engineer's Pocket Book," and his additions and corrections to this work were of national value. In 1905 Mr. Powles prepared a work on the "History and Development of Steam Boilers," which was published by Messrs. Constable and Co. This is particularly valuable on account of its historical notes on the subject.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—During the past week the coal market was thrown into a state of chaos by a Customs order "that the sailing of all British vessels with cargo of coal, coke and patent fuel, except cargoes coastwise, British Admiralty account and for British coaling stations abroad, is suspended." The effect of this announcement was that all British vessels loading for France, allied countries, Scandinavia and South America were prevented from sailing, while foreign ships that had not commenced loading were unable to obtain supplies, because of a refusal on the part of the authorities to release coals. The market was further unsettled by an authoritative statement from the South Wales representative of the Coal Controller that there was no general embargo on the export of coal. Yet at the same time it was impossible to get coals released for other than British coaling stations abroad and coastwise ports. Subsequently it was pointed out that the purpose of the apparently conflicting statements was to conserve our coal supplies for our own domestic requirements pending a settlement of the disputes in the English coalfield; also that loading operations would not be interfered with to such an extent as was likely to imperil the continuance of work at the pits, the main object of the Government being to secure as equitable a distribution as possible consistent with the object of minimising the effects of the coal shortage in the areas affected by the Yorkshire miners' strike. Foreign vessels loaded and partly loaded were allowed to proceed to sea, but a large number of British vessels with their cargoes were requisitioned and sent to United Kingdom ports, whilst those not already commenced loading were refused clearance and were held at the disposal of the authorities. At the same time collieries were supplied with wagons and instructed to load them up for despatch to English areas, mainly north-country, so as to prevent any shortage of coals on the railways and to keep essential industries working. The nearness of the holidays also aggravated the position. The Government have decided, in view of the reduction in outputs, to limit exports of coal to 23,000,000 tons per annum, compared with 73,000,000 tons in 1913. The pre-war and contemplated exports from the different districts in the United Kingdom is as follows:—

District.	1913. Tons.	New Scale. Tons.
Bristol Channel ...	29,875,916	13,000,000
Tyne ports ...	23,023,810	7,500,000
Humber ports ...	8,883,353	1,000,000
Scottish ports ...	10,437,197	1,500,000
Total (including other ports) ...	73,400,118	23,000,000

The quantity of bunker coal shipped in 1913 was 21,031,550 tons, and the maximum quantity under the new conditions will only be about 12,000,000 tons. Business on the Cardiff market has, under the present new state of affairs, been driven to an almost complete standstill, and operators are reluctant to fix up new transactions until the position becomes more settled and clearer. For the time being dealings are confined to securing odd parcels for the bunkering of steamers, cargo coals being practically unavailable. For next week's shipment sellers are indicating prices which are much higher than has ruled since the termination of the maximum prices. Admiralty coals are quoted up to 75*s.* for large, and those requiring supplies are obliged to pay 70*s.*, while small steams are also very tight and scarce, with as much as 60*s.* demanded for the best qualities and from 50*s.* for the inferior sorts. Coke makers have advanced their prices 10*s.* to inland consumers in view of the increase of 6*s.* placed upon coal prices, and coke at oven for blast-furnace purposes is now at a minimum of 52*s.* 6*d.*, and for other purposes 65*s.* 6*d.*, while for export 70*s.* is demanded. Patent fuel is also scarce and firm at 65*s.*, for export to allied countries and 70*s.* for other countries.

Newport.—There have been a number of stoppages in the Monmouthshire coalfield during the past week for various causes. Outputs have in consequence been considerably reduced.

THE SALE OF LEATHER BELTING.—Hitherto it has been the English custom to sell leather belting chiefly by weight, and where sold by measurement leather belting has usually been sold without any specified thicknesses. Both of these systems are so obviously open to objection from a buyer's point of view, and both have such weak points compared with some of the Continental systems, that the Federation of Leather Belting Manufacturers of the United Kingdom have decided that after September 1, no leather belting shall be sold, except on the basis of the new National Price List, which quotes for all widths of belting per foot, with thicknesses specified according to the customers' requirements and the purpose for which the belting is intended. Copies of the new list will be circulated to all buyers in the Kingdom before September 1, and the federation anticipates that the change will be welcomed by buyers, who will in future know exactly what their belting is going to cost them, and exactly what is going to be supplied for the money. It has long been an anomaly that all other classes of belting have been sold by measurement, with thicknesses or plies specified. The change is being made by the federation entirely in buyers' interests, and, with a view to bringing the leather belting trade of the United Kingdom up to the highest possible standard in the early days of reconstruction.

THE DEVELOPMENT OF TURBINE MACHINERY FOR H.M. TORPEDO-BOAT DESTROYERS.

(For Description, see Page 130.)

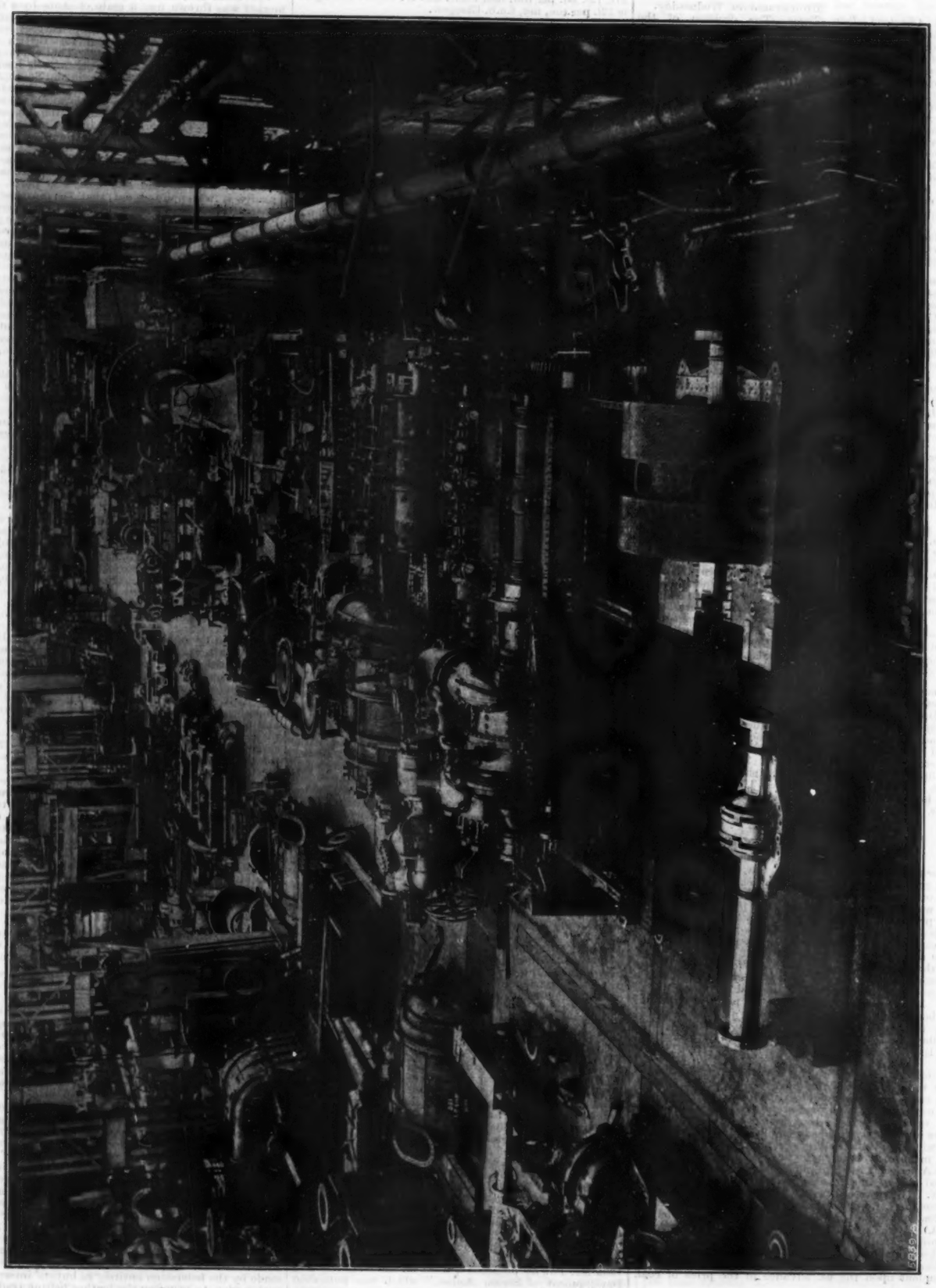


Fig. 5. View of All-Geared Turbines for Destroyers of "S," "T" and "V" Types; Constructed by Messrs. William Beardmore and Co., Limited, Dalmuir.

THE DEVELOPMENT OF TURBINE MACHINERY FOR H.M. TORPEDO-BOAT DESTROYERS.

(*For Description, see Page* 139.)

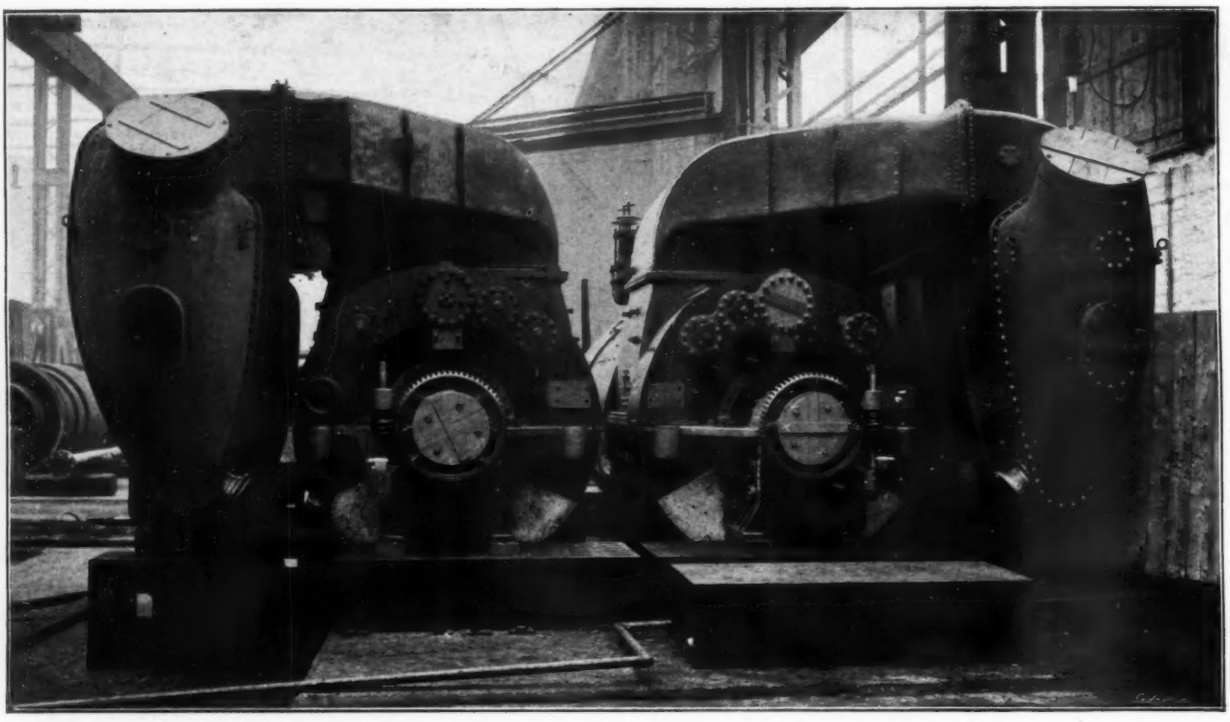


Fig. 1. Aft End of One Set of Twin-Screw Direct-Drive Turbines for "L" Class of Destroyer.

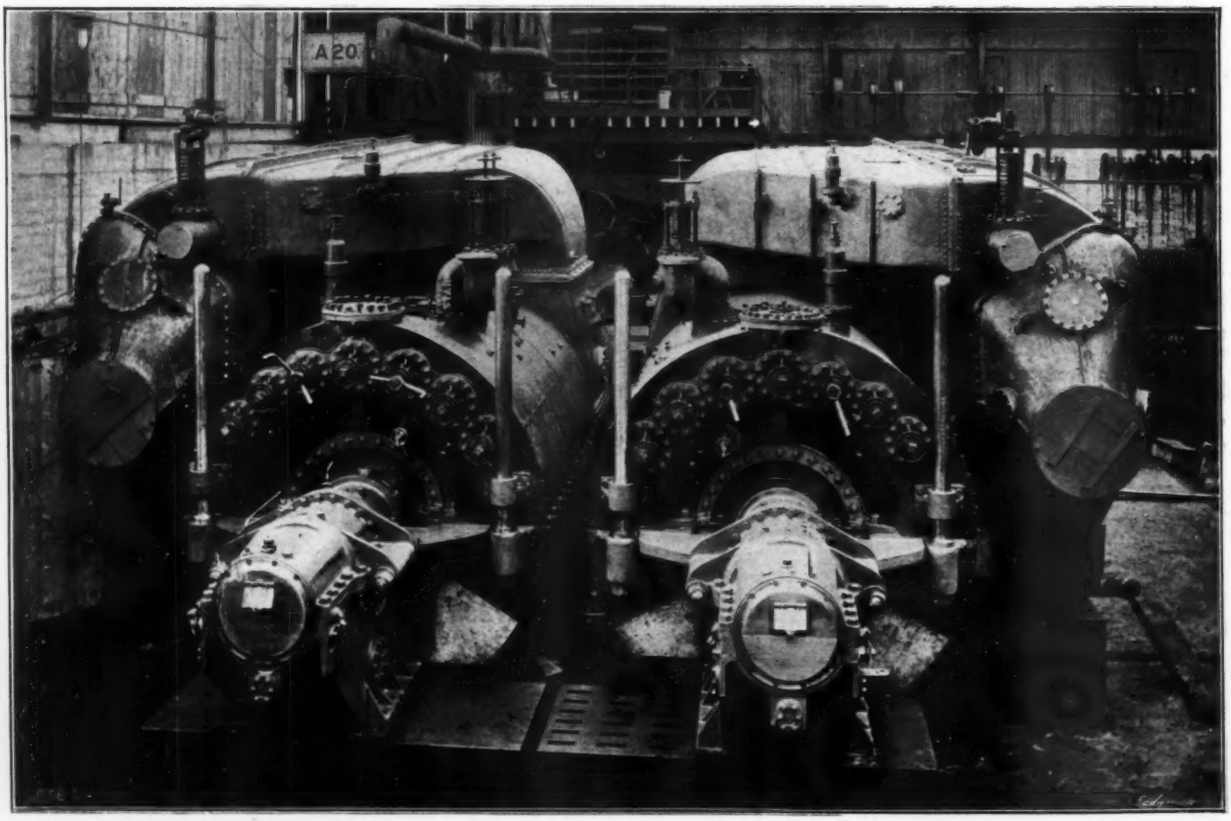


Fig. 2. Forward End of same Turbines; Constructed by Messrs. William Beardmore and Co., Limited, Dalmuir.

THE DEVELOPMENT OF TURBINE MACHINERY FOR H.M. TORPEDO-BOAT DESTROYERS.

(*For Description, see Page* 139.)

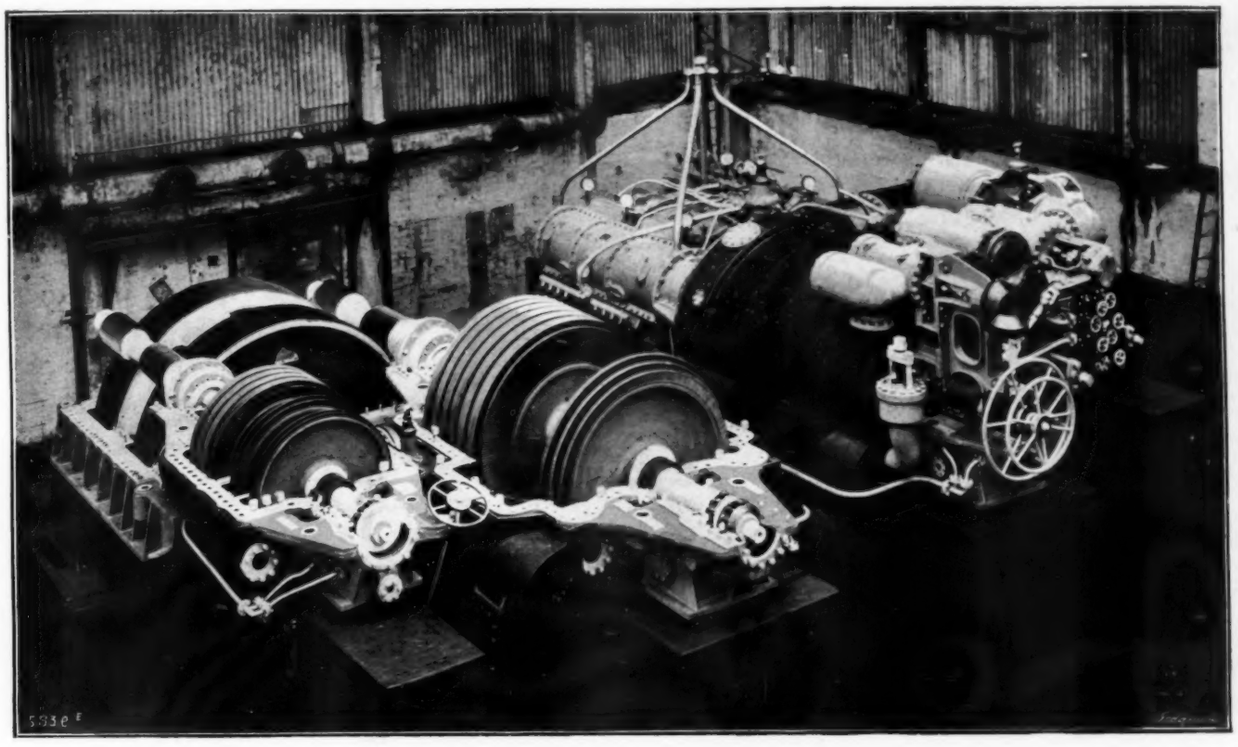


Fig. 3. Two Sets of Twin-Screw All-Geared Turbines for H.M.S. "Wild Swan."

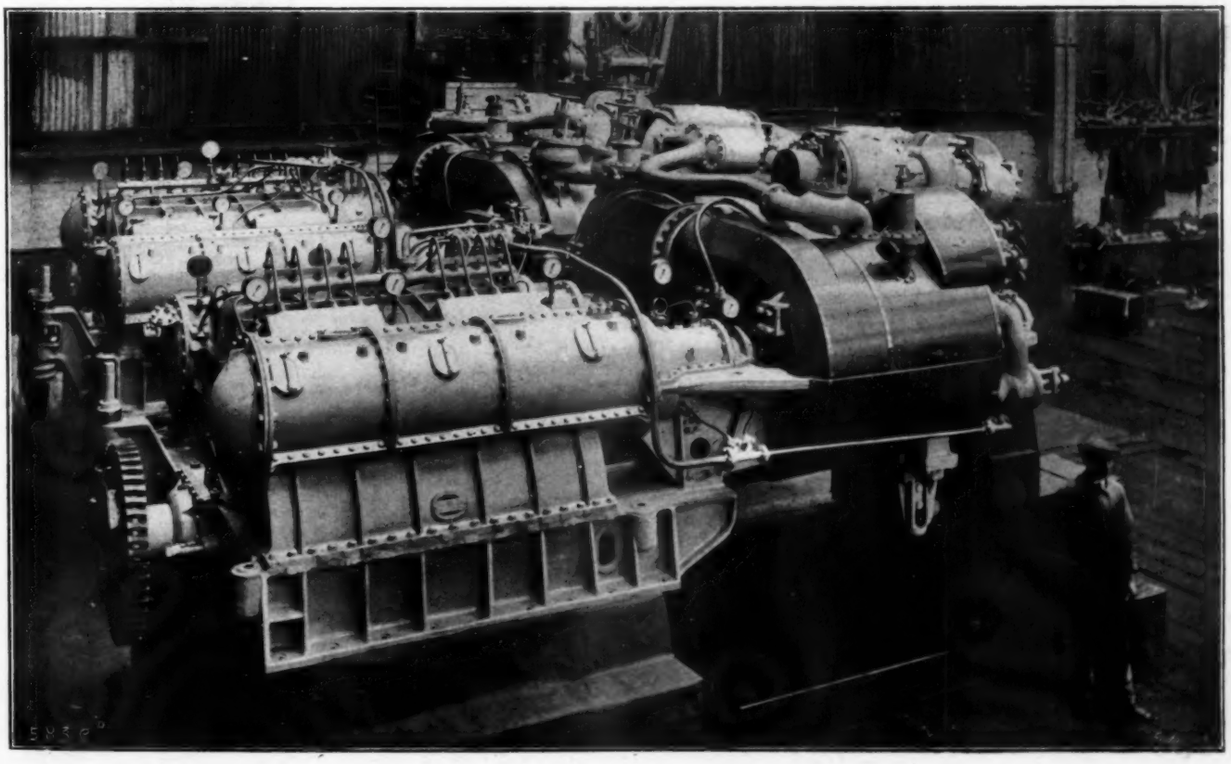


Fig. 4. Broadside View of same Sets of Turbines; Constructed by the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne.

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Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C. 2.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON,

TELEPHONE NUMBERS—3663 and 8598 GERRARD.

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NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper and the consequent shortage of Supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

ENGINEERING.

FRIDAY, AUGUST 1, 1919.

THE NEW PATENTS BILL.

THE House of Commons has now under consideration the Government Bill to amend the Patents and Designs Act, 1907, which was read a second time on Monday last. Two years ago the Government introduced a Bill having a similar object, but it was withdrawn. It is generally understood that the 1917 Bill was allowed to drop because the Government found that it was not as they imagined, a non-contentious measure. We think the Government will find that the new Bill is also not a non-contentious measure. The 1907 Act introduced into British Patent Law what is known as compulsory working. The alteration in the law was hailed with enthusiasm by some and was regarded as a retrograde step by others. We were sceptical, and even now are sceptics with regard to compulsory working. The compulsory working section of the 1907 Act did not do what it was expected to do by its advocates, and as a consequence the Government are now throwing compulsory working overboard and are proposing in lieu thereof a series of provisions which they hope will have the effect of controlling, in the interests of the public, the monopoly which the granting of a patent gives.

Section 1 of the new Bill provides that any interested person may apply to the Comptroller alleging that there has been an abuse of the monopoly rights under a patent and asking for relief. Five sets of circumstances are specified as constituting abuse, they are: (*a*) Non-working on a commercial scale in the United Kingdom without satisfactory reason; (*b*) prevention or hindering of working in the United Kingdom due to importation from abroad by, or on behalf, or with the consent of, or without effective interference by, the patentee; (*c*) demand for the patented article in the United Kingdom not met to an adequate extent and on reasonable terms; (*d*) any trade or industry prejudiced by refusal of the patentee to grant licences on reasonable terms; (*e*) any trade or industry prejudiced by conditions attached by the patentee to the purchase or use of the patented article.

The Comptroller is to be vested with remedies, also five in number, viz.: (*a*) He may endorse the patent with the words "Licences of Right" after which any one can obtain a licence on complying with certain conditions; (*b*) he may order the grant of a non-exclusive licence to the petitioner; (*c*) he may, in certain circumstances, order the grant of an exclusive licence to the petitioner, or to some other person; (*d*) he may revoke the patent; (*e*) he may make no order.

The section also contains many sub-sections dealing with the machinery and directions for carrying it into effect. The new proposal is certainly better than compulsory working, but it is not one with which we are enamoured. There are, it seems to us, much better and easier ways of protecting the public from the danger of patentees holding up their patent rights to the hurt of the common weal. If a patentee does not exercise his monopoly so as to give substantial benefit to the public it is open to any interested party to apply for a compulsory licence, and non-working is a good ground for granting such a licence. It is true that the 1907 Act contained a compulsory licence clause, but the machinery to be set in motion was so involved and costly that little or nothing has been done to give effect to this part of our patent law. The procedure laid down in the 1907 Act was an improvement on that contained in earlier Acts, but it can be improved and that very simply. The new Bill proposes to cancel the compulsory licence clause of the 1907 Act and to institute a procedure by which a patentee may have his patent endorsed with the words "Licences of Right," whereupon any person is entitled to the grant of a licence under the patent upon terms to be fixed either by agreement between the patentee and the applicant, or in default, by the Comptroller. Sections 1 and 2 of the new Bill are thus interlinked, as one of the remedies provided for abuse of monopoly rights is, as we have stated above, the endorsing of a patent with the words "Licences of Right" upon which the rules that apply to Section 2 come into force.

The new section will bring our law into line to some extent with the Canadian law, under which a patentee may have his patent endorsed as subject to the compulsory licence provisions of the Canadian Act. It will not be an improvement in our law to provide complicated machinery under which a person desiring a compulsory licence must first apply under Section 1 and prove abuse of monopoly right before he can obtain a licence of right under Section 2, and this is what the new Bill proposes should be done when a patentee has not of himself had his patent endorsed "Licences of Right." A person wishing for a compulsory licence should be given the power to apply to the Comptroller directly for the grant of such a licence, and such a licence should be granted on proof that the reasonable requirements of the public are not met, or that the applicant is prevented from working another invention in which he is interested. The simple and relatively inexpensive machinery already existing in the Patent Office would be sufficient for dealing with the matter.

The abandoned 1917 Bill was subject to much criticism, and at the time it was introduced into Parliament we did not hesitate to express our opinion of several of the new provisions it contained. As we have already stated, we think that the new Bill will, like its still-born predecessor, be subject to hostile criticism. In certain respects the two Bills are practically identical and the Government have treated with contumely the representations made to them by the deputation to the Board of Trade in October last. It will be remembered that the Institution of Electrical Engineers appointed a committee to consider the 1917 Bill, and this committee issued a report, which was a very illuminating document. Subject to a few verbal alterations this report was adopted by a conference of representatives of some 30 of the leading scientific and technical societies convened by the Institution of Mechanical Engineers. A representative deputation was appointed and waited upon the President of the Board of Trade when the report formed the basis of the representations made to him by the deputation. It was thought that the pressure thus put upon the then President of the Board of Trade would have had some effect, but an examination of the new Bill shows that of the suggestions made by the deputation, only one has been accepted in its entirety, and that is the extension of the term of the life of patents, but this is a small matter, as the 1917 Bill already provided that this should take place by Order in Council. We understood the Government regard the new Bill as a non-contentious measure, but they will certainly find that they are mistaken. Evidence proves that a large body of patentees and inventors are in antagonism with proposals contained in the new Bill and that steps are at once being taken to fight its progress through Committee.

The new Bill proposes to lengthen the life of British patents, and it is now suggested that patents shall be granted for a term of sixteen years. The Government have evidently not turned a deaf ear to the demands that have been made for many years for an extension of patent term. The proposal is certainly an improvement, but we would have been better pleased if seventeen years had been suggested, thus bringing British and American patent practice into line in one particular. It is also proposed to restore the term of provisional protection to nine months and extend the time for acceptance to fifteen months. The first proposal is certainly an improvement, but the period of six months from the date of filing the complete specification allowed for examination by the Patent Office and amendment by the applicant as a result of that examination is, as experience has proved, totally inadequate. It would have been better to have allowed a further

term of, say, three months or eighteen months from the date of application for obtaining acceptance, with the possibility of extending this term, as at present, by three months, on payment of a fine.

We have pointed out on several occasions the great hardships which patentees were suffering owing to the impossibility during the war of working many of their inventions, and we suggested that patentees should be given a chance, at the conclusion of the war, to obtain a prolongation of their rights, on the presentation of proof of the disabilities which they had suffered. The new Bill contains proposals in this direction, but the proposals do not go far enough. The 1917 Bill proposed to give a patentee the right to apply for prolongation, even if his patent had expired, and the omission to do so in due time was attributable to circumstances connected with the war, but the new Bill only proposes to give the court power in its discretion to extend the period within which a petition may be lodged. To obtain a prolongation of a patent in the ordinary course, the court has regard to the nature and merits of the invention in relation to the public, to the profits made by the patentee, and to other circumstances, and the court is now to be directed that it is to consider loss which may have been occasioned to the patentee by reason of the war. It will thus be seen that the amending Bill falls very short of what we proposed, and we think (1) that an extension for a period equal to the total duration of the war should, on application, be granted in the case of those patents which were in force when the war broke out and are still in force, (2) that in the case of patents which have expired by lapse of time during the war, the extension should be for a period equal to that from the commencement of the war to the end of the ordinary life of such patents, and (3) that for patents other than war patents which have been taken out since war commenced the extension should be for a period equal to that between the date of application and the end of the war. Patentees should bear in mind that the machinery provided for obtaining an extension of patent term is complicated and expensive and that when such a petition comes forward, it may be ten years hence, it will not be so easy to prove that they have sustained loss or damage by reason of the recent hostilities.

We should very much have liked to have seen proposals in the new Bill for the provision of machinery for adjudicating effectively upon actions involving technical matters and the establishment of a special division of the High Court of Justice to deal with such subjects; we should have liked also to have seen proposals by which appeals from the decision of the Comptroller were taken direct to such a court or to the courts instead of the law officers of the Crown. Patentees at the present time are suffering under great disadvantages owing to the amount of work which the law officers have to do, and in many cases three or four years elapse between the entering of an appeal and the time when it comes on for hearing. In some instances the hearing of the appeal has been so delayed that the patent has expired before the hearing day.

Sections 8 and 15 of the new Bill deserve the most particular attention of patentees as they will be placed under greater hardships than now obtain with regard to the use of their inventions and designs by Government Departments, their agents, contractors and others. The amending Bill introduces another novel point in connection with British law, and contains a section which provides that if any one or more claims in a specification are valid the court in an action for infringement may grant relief in respect of any of such claims which are infringed without regard to the invalidity of any other claim in the specification, that is to say, the patent will not be upset, as is the case now, if one claim be bad, but will be upheld for as much as is good. The grounds upon which opposition may be entered are also considerably extended. There are at present several grounds on which opposition may be entered, and one ground permits a person to oppose on the allegation that the invention sought to be patented has already been claimed in a complete specification of a patent of prior date. This ground is considerably enlarged in the amending Bill, which proposes to permit opposition to be entered on the ground that the invention has been published in a complete specification or in a provisional specification followed by a complete specification or in any document other than a British specification published in the United Kingdom prior to the date of the application opposed. This will open the door to opposition to the grant of a British patent on the ground of prior publication of the invention in a German or United States specification, or even in a newspaper article. The reform is a much needed one, and will assist to purify patent grants. The amendment will also open up other grounds on which a petition for revocation may be brought before the Comptroller. In respect of convention cases it will also be possible to oppose on the ground that the opposed application describes or claims an invention other than that for which protection was applied for abroad, and that such invention forms the subject of an application by the opponent made in the interval between the filing of the foreign application and the British application.

Patents of addition are also dealt with. At the present time, a patent of addition expires with the main patent. This is a hardship when the main patent is revoked, as the patent of addition may protect valuable subject-matter. The amending Bill provides that if the main patent be revoked, the patent of addition shall, if the Court of the Comptroller so orders, become an independent patent, subject to renewal fees, and with a life equal to the unexpired portion of the main patent.

We have not dealt with all the amendments contained in the new Bill, but only a few, and such as are of the greatest interest. From what has been said it is evident that the proposed amendments are of the greatest importance to all patentees. We should, however, very much have liked to have seen proposals widening the extent of the official examination as to novelty and bringing within its purview publications which are now beyond its scope.

AERONAUTICAL TERMS AND SYMBOLS.

In a science such as aeronautics, which has developed with great rapidity, and is divided into several more or less distinct branches, it is by no means surprising that some confusion as to nomenclature should arise. This was recognised as early as December, 1909, when the Aeronautical Society appointed a committee to draw up a preliminary list of aeronautical terms. This list was extended in September, 1914, but the need for further extension having become evident by October, 1916, it was then decided to compile a list which should be as complete and authoritative as possible. The results of the labours of the Technical Terms Committee, then formed, have recently been issued in the form of a glossary,* which, though admittedly incomplete, will, it is hoped, serve as a working compromise for the meantime. Later editions will be issued with improvements, extensions and emendations, which experience shows to be desirable. The committee have endeavoured not to create new terms, but where different terms have been applied to the same object, or operation, their aim has been to select the dominant term, or the one most logically defensible. The applications of many terms in common use have been clearly defined, and, although references are frequently made to colloquial expressions, no formal status has been allotted to them.

Students of aerodynamical problems have long recognised the need for uniformity in the symbols used for mathematical investigations of the subject, and should therefore welcome the committee's work in this respect. The list of symbols given in the glossary has been decided on after very careful consideration, and it is to be hoped that it will be generally adopted. Changes, although not easy to make now, will become of greatly increased difficulty as the literature of the subject extends. Duplication of symbols has been avoided as far as possible, and has only been permitted in cases where confusion is not likely to result. For instance, D is used both for drag and for the diameter of an airscrew, L is used for lift and for rolling moment, and ϕ may mean either angle of bank or the angle of the helix traced out by an airscrew. Areas of surfaces are designated by S instead of by A, as the former is generally used for this purpose in French literature. V, being commonly employed, both in English and French, for velocity, has been adopted for flight speed and resultant velocity, while V_i is used to represent the indicated air speed. This latter quantity, which is the product of V and the square root of the relative density of the fluid, has been given on account of its frequent occurrence, and because, in certain calculations, it is of more importance than V. The symbol σ has been introduced to represent the relative density, whilst ρ has been reserved to indicate absolute density.

The committee recommends the adoption of a new system of co-ordinate axes for use in the dynamical theory of aeroplane motion. On this system the axis of X is measured horizontally forward from the centre of gravity of the machine, Y is measured horizontally to the right hand and Z is measured vertically downwards. These axes give the flight speed, angle of incidence, thrust and weight all positive, and a positive bank corresponds with a positive turn. Air resistances and forces, including lift, are, however, negative, as also is the rate of climb. We agree that the system which most completely satisfies the physical conceptions as to the quantities involved is the best to employ, and that the proposed system possesses advantages, in this respect, over the two others at present in use. It is therefore greatly to be hoped that mathematicians will adopt the new system, and that no further changes will be found necessary. The theory of aeroplane stability is troublesome in any case, and the student's difficulties are considerably increased if he finds a different system of axes used in each of his text books. A new system of absolute coefficients for the forces and moments on an aeroplane, and for the resistance derivatives, is also put forward. The coefficients obtained by the method proposed have the advantage of enabling useful comparisons between the aerodynamic properties of two aeroplanes to be made by comparing the coefficients of the derivatives, as well as of being independent of the system of units employed.

In arranging and classifying the glossary, the Dewey decimal system, which was developed by the Institut International de Bibliographie, has been adopted as being logical, convenient and of universal application; an appendix explaining the system is, however, included for the use of those not already familiar with it, and an ordinary alphabetical index is also given. The main divisions are devoted to the dynamical theory of aeroplane motion, meteorology, aeroplane engines, component parts of aeroplanes and airships, instruments and apparatus, and timber. Illustrations have been used in some cases to assist the description of certain parts, and we would suggest that, in future editions, it would be advantageous to employ them to a much larger extent; foreign users would certainly find the illustrations helpful. As it stands, however, the glossary is undoubtedly a valuable piece of work, and should do much to bring about the highly-desirable uniformity in aeronautical terms throughout the English-speaking world. Moreover, as comment and criticism are invited from all interested parties, such imperfections as it may now contain should soon be eliminated. The work as a whole has been approved by the Engineering Standards Association, and the schedule of aerodynamical symbols has been accepted by the Advisory Committee for Aeronautics.

* *A Glossary of Aeronautical Terms.* London: The Royal Aeronautical Society, 7, Albemarle-street, W.1. [Price 2s. 6d.]

THE FEATURES OF MANAGEMENT.

A captain of industry may or may not be a master of craft, he was at one time, but to-day he is more properly the clearing house for trouble, he is the concentration point where separated activities conjoin, he forms both the vanishing and measuring points of the perspective projection of production, all the lines intersect in and through him to a common end. It is very easy to command "let this be," but that is only the prospectus of the promoter, who allows room for subsequent activity, and subscription does not create, it simply allows

creation to take place. Conception is not birth, it is only one precedent phase antedating nativity. The subsequent steps are wrought out painfully by those charged with the custody of production.

The view-point of the focal man must therefore inevitably differ, his responsibilities include the default or omission of every unit in the organisation. To a limited extent every responsible unit is in like case, their troubles are not their own but are the vicarious burden borne by them on other men's account, they have to shoulder the heat and burden of the day and play the part of Providence to their charges. No human life can divest itself of such external burdens nor should it attempt the task of transference if selected for their incidence.

The man proved competent in another sphere where control is more absolute, finds to his surprise that trivialities assume new significance in the pivotal chair; the worries inseparable from this altitude are always due to the lesser fault which is apt instantaneously to become of supreme importance. Development of all human faculties is contingent upon responsibility.

Fortunately troubles come singly, as single spies not in whole battalions, otherwise direction would be insupportable and the machine pause indefinitely, no one man could carry the burden. There is no other road, the captain of industry under any system must in deed and fact be an absolute autocrat, interference and revision of his instructions cannot be brooked without disaster. After his word has passed argument cannot be admitted or formulated. Obviously, therefore, he is a tyrant, equally his tyranny is tempered with real sense.

A committee or direction board may find wisdom in a multitude of counsellors, the man they delegate to interpret their wishes or carry out their commands must be unfettered in his discretion, occupy an independent orbit and not be held to account for every trivial occurrence. The commander or master of a ship treats his owner *en voyage* as a mere passenger without navigating rights, exactly so, it is mere sense. Yet some interested individual will attempt the thankless task of showing the management how to overcome some onerous restriction or turn a queer corner, and interference of this type is to be utterly condemned.

Swift intelligence, large mental grasp, instantaneous decision must be outstanding characteristics for the navigation of a vessel or control of a works; faltering, inconsequent indecision, half revision, irresponsibility cannot be tolerated. The leader must have reflective capacity and defer decision in grave cases; he cannot without fatal weakness withdraw subsequently after judgment is pronounced. He cannot act subject to a court of appeal above his authority. An executive committee or assembly of like character has one object; however capable apart each individual member may be, it exists for the additional emphasis of one of its members; he may not be the most influential or have the greatest interest, but he has the greater personality. The council assembles for his discovery and forms then a chorus as a background. Half the troubles of committee work are in the initial stages before *the* man emerges. Not that he is infallible when found, being human he is apt to err, but he is right in the greater majority of instances and divination and intuition to say nothing of tact and discrimination are his birthright, subject to development under cultivation.

There may be a multitude of alternatives, but only one expedient course, and this a matter of compromise; the right man senses this first, holds to it tenaciously, but has perchance to wait events for confirmation and proof of his wisdom and foresight.

It is possible to do the right thing at the wrong time, the wrong thing at the immediate moment, the right thing in the wrong way, the wrong thing in the right way; it is quite easy to misjudge distance, to calculate without due consideration of all the factors. To do the right thing at the right time, the one expedient at the inevitable moment is proof of administrative ability and is statesmanship of no mean order.

There are several separated masses in a corporate body; shareholders, directors, staff and workpeople; it has always yet been found necessary to intersect the joining lines through one common focus and there locate one man. To be this focal point of large issues is no mean or unworthy destiny, and rarely has the remuneration been commensurate. The tendency of the present is, however, more sensible; it is to select with due care the best and relieve him of all personal and domestic anxiety. Provided the right man is rightly located—there is never a superfluity of such men—this policy is right and fitting. The one link from which the diverse chains radiate to sling the load, supported by similar divisions from above, must be of sound workmanship, adequate scantling, and superior metal, there is no second chance should it fail and leave inextricable confusion and casualty in its train. The escapement must function correctly or time is not kept, a chronometer subje ct to heavy correction is even then undependable.

Many are called, few are chosen; not every individual of superior mentality upon whom the prospect exerts fascination and inflames ambition is adequate, too much depends upon the post for wrong selection to be easily remedied. A live surging load is carried, and the central link is most often a ring to allow true radiation of members, and to compensate automatically, without distortion, for the varying direction of stress. Yet the simile is inadequate because passivity is a negative virtue after all, while that continuous adaptation which is distinctive of all life must be an attribute of the occupant of the central chair.

Organisation is fabrication no less than production, it involves co-ordination, oversight, prevision, and the responsible man must be generous to a fault, making allowances, minimising defaults, setting the competent to balance the incompetent, working ceaselessly to a common end for which he serves. Mechanical industry and engineering effort have been rich in such men, whose reward is mainly in the memory of things accomplished and the approval of their own most critical selves.

NOTES.

University Degrees in Commerce.

In view of the fierce struggle for commercial supremacy, which has already commenced, and which will be developed enormously during the next few years, the recent proposal of the University of London to found degrees in commerce and to provide the training necessary for proceeding to them, becomes a matter of extreme importance, not only to the business community but to every citizen of the British Empire. Until quite recently there have been no universally recognised qualifying examinations for a man entering a business career corresponding to those which govern the entrance to most of the professions, and the business man usually obtained his training by entering an office, or factory, and picking up information as well as he could. This unsatisfactory state of affairs will be further modified by the University of London, now following other similar institutions. It is now proposed to provide firstly, a grounding in general business methods, including such subjects as economics, geography and languages, and, secondly, specialised training in particular subjects appropriate to the industry to which the student proposes to devote himself. The curriculum has been carefully considered and revised by committees representing the various trades concerned, so that the degrees, which will be granted to students who pass successfully through the course, should stand on an equally high footing with those already granted by the University in other faculties. To carry out their proposals the University authorities desire to found lectureships in many modern subjects, to provide a bureau for assisting students engaged during the day time, to endow scholarships, to collect and publish literature on commercial subjects, and to add commercial literature to the various libraries attached to the University. Certain extensions to the *personnel* and buildings will also be necessary to render the School of Commerce workable. For the proper establishment and endowment of the scheme it is estimated that a sum of about 500,000*l.* is needed, and an appeal, bearing the names of a large number of prominent supporters, has just been issued for contributions to this sum. It is pointed out that scientific training in business, the lack of which has hampered us in the past, will be of even greater importance in the very near future, and, for this reason, it is hoped that the means for putting the University scheme into operation will be provided with the minimum possible delay.

American Transatlantic Liners.

It has been announced in the daily press that the United States Shipping Board has completed plans for the construction, for the Transatlantic service, of two large liners which are designed to make the voyage in four days. The vessels, which will be built under the supervision of the Navy Department, will have a length of 1,000 ft., a beam of 102 ft., and a moulded depth of 74 ft. The gross tonnage will be 55,000, with a draught of 35 ft., and the designed speed is 30 knots. The power of the turbines is not stated, but they will be supplied with steam from boilers fired with oil fuel, of which sufficient will be carried for a voyage of 7,000 miles; the vessels will thus be able to complete the round voyage without refuelling. Accommodation will be provided for 3,000 passengers, and a crew of 1,000 will be carried. It is proposed to construct a special terminal for these vessels at Fort Pond Bay, Montauk Point, the most easterly point of Long Island, and this, besides relieving the congestion in New York Harbour, will reduce the length of the voyage to Plymouth by about 118 miles. The above announcement is of considerable interest, especially in view of the statement made in our last issue, on page 118, that no vessel at present under construction in this country has a gross tonnage exceeding 25,000. It thus threatens that the "blue ribbon of the Atlantic" will now go to the United States. Our fastest passenger steamer, the Mauretania, has a service speed of 25 knots, but its length is only 762 ft. The Aquitania and Olympic are both larger vessels, the former being 868 ft. in length and the latter 852 ft. long, but the speeds of these vessels are lower than that of the Mauretania, being 24 knots and 23 knots, respectively. The steamship Imperator, formerly owned by the Hamburg-American line, and now surrendered to Great Britain, has a length of 882 ft. with a speed of 23 knots, but the Americans have a larger and faster vessel in the ex-German liner Vaterland, since re-named Leviathan, which is 907 ft. in length and has a speed of 24 knots. It is not stated whether the new American ships will receive subsidies from the United States Government, but in view of the high working costs of such vessels, and also of the fact that they will be equipped to act as commerce destroyers in the event of war, there is every likelihood that such will be the case. The successful construction of these vessels will certainly be a notable achievement in naval architecture, but, in our view, it will be of less importance technically than the work of the British designers and builders who produced the battle-cruisers Repulse and Renown, having a speed of 32 knots, of which full particulars will be found on page 461 of our last volume. A still larger and faster British cruiser is nearing completion. This proves that our designers and builders only require the encouragement to excel the American project. The commercial importance of the American ships, however, must not be underrated, as they cannot fail to have considerable effect on Atlantic passenger traffic.

Stratification of Soap Films.

Studying soap films under the microscope, Professor Jean Perrin, of Paris, made some peculiar observations. That black spots develop on such films, and that the thinnest black films are the most stable, had long been known. Perrin refers only in this connection to Johonnott, who, in 1906, counted five orders of black spots; he does not mention the recent work of Sir James Dewar who, working in special dust-free atmospheres, is able to keep large films, several feet in diameter, for many weeks. Perrin illuminates his film by a small arc light in such a way that the direct light does not enter the eye at all; and he then notices that tiny spherules, apparently of water, dance about in intensive Brownian movements on the blackest films, floating apparently above the film and not in contact with it, to judge by the rapidity of their movements. The appearance seems to be that

of the Leidenfrost phenomenon, though Perrin does not speak of these analogues (*Annales de Physique*, September-October, 1918). The second point is that he added small percentages of fluorescent solutions (uranin, &c.) to the soap solution. The number of distinct spots then became very much greater; he counted, *e.g.*, 18 black, gray and white spots, 17 or 18 yellow and red spots, and 1 violet. Each of these spots appears in its own colour and is bounded by circular arcs, and the colours are evidently due to the superposition of films in parallel layers, suggesting a regular stratification. The Brownian movements cease as the thickness increases. When the illumination is so arranged that half a circle is light and the other half dark, the stratification is first confined to the illuminated half, but it soon spreads over into the dark region. The development of a stratification is thus favoured by light; it is also facilitated by a rise of temperature. Stratification is further observed in aqueous emulsions of resins like colophony, when they are rendered alkaline with caustic soda, without adding any soap or oil, however. To judge by the interference colours there may be 40 spots superposed, ranging in thickness up to 250 $\mu\,\mu$, and the thicknesses of the layers seem to increase by steps of 5 $\mu\,\mu$. All this suggests that the layers are of the nature of liquid crystals. There is further, with soap films, a difference between the superficial layer and the interior. That the surface layer has a very low surface tension, has long been recognised, and it has been assumed that the soap, which is generally sodium oleate, is hydrolysed, and that the superficial layer consists essentially of free oleic acid, while the soda concentrates in the interior. With the assistance of Professor Delmon, a lady from Buenos Ayres, Perrin has actually demonstrated this hydrolysis. When air is blown through a soap solution, a fine foam rises on the surface; by making this foam escape over the edge of the vessel, Perrin separated the surface foam from the interior layer, and found the foam to be acid and oily. Quantitative experiments show that the foam-forming acid layer on the top has a thickness of about 2 $\mu\,\mu$ and would probably be bimolecular, therefore, that is to say, it would represent a layer two molecules in depth.

THE BRITISH SCIENTIFIC PRODUCTS EXHIBITION.

(*Concluded from page* 123.)

Metallurgy, Furnaces.—Metallurgy is not strongly represented, but furnaces are shown in great variety, mostly by firms noticed last year. The August Muffle Furnace Company, of Halifax, generally uses coke fuel (up to 1,000 deg. C.), but preheats the annealing and hardening furnaces by waste heat, and makes use also of gas fuel, oil and electricity in the rotating, brass and other furnaces. In the Lane core-heating furnaces seven chambers, each under separate control, are heated from one fire-box. The firm also shows a large agricultural machine for soil sterilisation. The recuperative producer gas-fired furnaces of Mr. A. Hermansen, 66½ Corporation-street, Birmingham, were described by T. Teisen before the Society of Glass Technology in May, 1917; their four 6-crucible units erected for Messrs. Blakeborough & Sons, Brighthouse, are serving for Admiralty gun-metal castings; the furnace for Messrs. Senior & Co., of Sheffield, is used for re-heating alloy-steels; the fire-clay tubes, square in section, are a special feature of these furnaces. Mr. Hermansen also shows his thermometer tubing of slightly greenish glass. The refractory fire-bricks and clays of the Leeds Fireclay Company, Leeds, withstand temperatures up to 1,770 deg. C.; their frittite cement for repairing tiles and for rendering coke-oven and retort settings of gas- and air-tight is a novelty.

Messrs. John Wright & Co., of Birmingham, combine their furnaces for glass, high-speed steels, &c., with their auto-gas producer. The producers, sunk below the floor, are of the suction type; they are built in iron and mild steel, fire-brick lined, and provided with special fire bars, grooved rods, the four grooves of which are supplied with water rom a ball-valve tank; steam is thus generated, and the protruding square ends of the bar are turned by means of a hand lever. In the glass tanks temperatures of 1,400 deg. C. are maintained, and the emptied tank can be repaired without disturbing the recuperative furnace; the auto gas passes through dust-traps. The "quenchoid" and "feusalt" of the firm are salt baths for quenching carbon steel and high-speed steel; the "pyromelt" and "tempermelt" and lead baths serve for the same purpose, and the Wright-Brayshaw furnaces are designed for handling the work in these temper-baths. In the "Lopress" furnaces for high-temperature treatment, a fan supplies the pre-heated air to the burners.

Smaller furnaces and muffles, more of the laboratory and testing type, are exhibited by a number of firms, among which we notice Messrs. Gallenkamp & Co., of 19-21 Sun-street, E.C. 2, who also show Mahler-Kroeker bomb calorimeters and the furnaces for heating the Lessing silica tubes, designed for comparing the coking properties of coal. The tubes resemble test-tubes with a lateral gas outlet. The coal under test, 1 gramme as a rule, is placed, not directly into this tube which serves as retort, but into a smaller inner tube, and is loosely held in place by a small silica piston to prevent spurting of coal particles and to exclude the air. The retort can be raised or lowered within the furnace so as to bring it into zones of different temperatures. The new centrifugal machines of Messrs. Gallenkamp, the buckets and perforated drums (14 in. diameter) of which are made of porcelain, can be worked at 1,000 r.p.m. More of chemical interest than these machines are the copper-coated flasks of the firm; the external coating of copper (electrolytically deposited on a film of silver first reduced, we believe, on the glass) covers the bottoms and sides of the flask and distributes the burner-heat rapidly; the metal prevents the loss of the liquid, moreover, if the glass should crack.

Passing to metallic products we notice the fine exhibits of the Aluminium Plant and Vessel Company, of Point Pleasant, S.W. 18, large and small-size vessels of aluminium, mostly high-grade of 99 per cent., for dealing with edible oils, fats, and chemicals generally, petrol tanks, a deodorising plant, further die-casting elbows, radiators, centrifugal pumps, &c. To keep their colour and transparency enamel varnishes—*e.g.*, the metoline enamel of Messrs. Thomas Parsons as shown on the stand—should be made in aluminium vessels. Silicon and iron are practically the only impurities of aluminium now, and 0·13 per cent. of iron is not considered injurious to the durability of the metal, which is not corroded by concentrated and diluted nitric and sulphuric acids, though it does not stand hydrochloric acid and alkalis; sodium is an undesirable impurity, of course. The firm is very successful in welding its aluminium with oxy-acetylene; the point is to get rid of the fine oxide film on the aluminium and to prevent its formation during the welding; aluminium soldering, generally done with the aid of tin, zinc, and aluminium, is less satisfactory. Messrs. H. L. Raphael, of Thomas-street, Limehouse, E., refiners of gold and silver bullion and of aluminium scrap and swarf, confine their exhibits to aluminium ingots cast in sand, metal-mould die castings, small and large of all descriptions for aircraft and motor vehicles, requiring no finish, and to their extruded aluminium rods and tubes. The fluid metal or alloy is forced by hydraulic rams through dies; the rods are made in sizes from ¼ in. up to 3 in. diameter, the tubes of ⅛ in. wall-thickness, in sizes from 3 in. down, and with a wall thickness of $\frac{1}{32}$ in. from ½ in. down to ¼ in. diameter; the tensile strength of the alloys ranges from 14 up to 20 tons per sq. in. Aluminium sticks, used for steel refining, are likewise among Messrs. Raphael's exhibits.

A very fine collection of metallurgically-important alloys and ferro-metals and non-ferrous carbon-free alloys is displayed by Messrs. Kent Smith, of Attercliffe, Sheffield. The exhibits of Messrs. Johnson, Matthey & Co., are remarkable for their pure precious metals and heavy and rare elements and their compounds. The metallic magnesium metal and powders of gold, bronze, aluminium, &c., of the Magnesium Metal Company and Metal Powders, of 34A Buckingham Palace-road, S.W. 1 claim attention because their uses are much increasing.

Physics Section: Optical Apparatus, Rangefinders and Selenium.—The catalogue of the Physics Section comprises a varied range of apparatus, among which optical instruments used for war services, such as the 30-ft. base range-finders and the periscopes, 30 ft. long, of Messrs. Barr and Stroud, Limited, of Glasgow, are prominent. We commence on another page of this present issue a short series of articles on Messrs. Barr and Stroud's work, and as in the course of these articles the range-finders and other optical appliances for which the firm has established such a reputation will be fully dealt with, it is unnecessary that we should give any description of them here. All we need say is that the exhibits are of exceptional interest, and will well repay careful examination. Nearly all the optical glass of Messrs. Barr and Stroud, including borosilicates and other kinds exhibited, is now made by the firm in gas-fired and electric furnaces, the firm making likewise the pots in unusual sizes, and the lens-grinding machinery. Of the binocular prisms shown, more than 120,000 have been supplied to the Government. The electric fire-control instruments and water-tight door indicators form other specialities, and there is finally on view, so far only in model, a new type of optophone—an instrument designed to enable the blind to read by hearing—the joint invention of Dr. Fournier d'Albe, whose optophone we have noticed on previous occasions, and of Messrs. Barr and Stroud.

The selenium cells of Dr. E. E. Fournier d'Albe, of 10, St. James'-terrace, N.W.8, consist of thin plates of a special porcelain, about 1 in. sq., which are coated with graphite by means of a brush. Into the polished surface zig-zag lines are ruled with a diamond, and black selenium—the red modification is not suitable—is wiped into the fine grooves. When the cells are especially mounted to serve as relays, they are called tablets. For relays, the surface should be large and the resistance low; for the photophone cells of small surface and high resistance are used; the cells of the optophone are of very high resistance. The ship's course tell-tale controller, the invention of Major W. Buddicom, late of the Tank Department, is operated by selenium cells which give an audible or visible warning (by a red or green lamp), when the ship is off her prescribed course; the device is designed to serve as a safety appliance and as a recorder for ocean-going ships, in addition to the ordinary binnacles.

Of the members of the British Optical Instrument Manufacturers' Association, the following firms and other firms, some chiefly represented in group exhibits, we briefly mention: Messrs. C. Baker, of 244, High Holborn, W.C.1 (microscopes); R. and J. Beck, of 68, Cornhill, E.C.3 (lenses, telescopes, periscopes); Bellingham and Stanley, 71, Hornsey Rise, N.19 (immersion refractometer with interchangeable prisms, Lippich polarimeter for standardisation); G. H. Dallmeyer, Willesden, N.W.10; Heath and Co., New Eltham, S.E.9; Ross, Ltd., North Side, Clapham Common, S.W.4 (sights, periscopes, telescopes, cameras—chiefly war instruments); W. F. Stanley and Co., 286, High Holborn, W.C.1; and A. G. Thornton, King-street West, Manchester.

Optical Glass and Instruments.—Messrs. Chance Brothers, of Smethwick, Birmingham, make a very fine display of their 70 optical glasses of all kinds, comprising several novelties for this country, in plates, moulded prisms and discs, fluor-crowns, extra light and dense flints and crowns, zinc crowns, borosilicates, uranium glass for fluorescent screens, and a 28-in. crown glass disc for an astronomical refractor. Among these special sheet glasses, we notice Crookes spectacle glass, colourless and yellow-green; an opaque glass, ⅛ in. thick, for the transmission of ultraviolet; neutral glass for sextants, green signal glass, arc screen glass and antifade glass for the protection of colours from ultraviolet and other rays. Mention should also be made of the great variety of heat-resisting glass, globes, chimneys, bulbs &c. The Derby Crown Glass Company, Limited, of Little Chester, Derby, demonstrate by their exhibits the raw materials and finished products (some 50 optical glasses),

and some difficulties experienced in their manufacture.

A good deal more optical glass, together with many of the instruments, in which the firm specialises, can be seen in the cases of Messrs. A. Hilger, Limited, 75a, Camden-road, N.W.1. New to our readers may be the Nutting photometer, which, combined with the wave-length spectrometer of the firm, makes a very convenient form of spectro-photometer, designed especially for studying the absorption spectra of liquids and solids, the selective absorption of dyed fabrics, and for comparing (with the additional aid of two right-angled prisms) two separate light sources: the quartz spectrographs with the ultraviolet spectrophotometer and the infra-red spectrometer. Used in conjunction with the sensitive thermopiles of Messrs. Hilger (built up of bismuth and silver), this latter instrument allows of extending spectrophotometry from the visible into the infra-red (up to 10 μ). The essential parts of this instrument are: a rock-salt prism (kept in a glass bottle when not in use); two concave mirrors and one plane mirror, all gilded by the firm's process; the thermopile and its galvanometer; and two symmetrical slits, in the second of which the thermopile is inserted. The light entering from the first slit is collimated by the first concave mirror and passes through the prism to the plane mirror; reflected back, it falls on the second mirror which forms the image of the spectrum on the second slit; the prism and plane mirror turn with the tables on which they are mounted; the thermopile is protected from external radiation by its nickel case. The infra-red radiation falling on the thermopile, deflects a galvanometer, which thus reveals the presence of an invisible line in the particular part of the spectrum. Thermal radiations from other parts of the spectrum are weaker, but lines can in this way be detected even in the ultraviolet. Papers on these instruments and on the researches connected with them have been published by Messrs. F. Twyman, L. Silberstein, F. Simeon, and J. N. Goldsmith, of Messrs. Hilgar's research department.

The chief speciality of Messrs. T. Cooke and Sons, of Buckingham Works, York, are their new mining theodolites, instruments in which Germany was decidedly leading. An accessory of these instruments, the small circular spirit-levels—the glass capsules of which consist of two parts fused together, so that leakage is rendered impossible—and the irrigation and drainage levels, should be noticed. The 4-in. theodolite in the centre of the stand was used by Captain Scott in the ill-fated Antarctic Expedition of 1910-11. The direct-reading tacheometer, which gives heights and distance without calculations, was illustrated in our issue of October 22, 1915, page 419. The very simple Waymouth-Cooke hand naval range-finder (Taylor and Gray patent) consists of a graduated disc, about 6 in. in diameter, from the plane of which a central ring projects, and to which a small telescope is attached. The object lens of this telescope is vertically split; the one half is stationary, the other can be shifted up and down. Looking through the telescope, the observer sees, *e.g.*, the mast of a ship; by turning the central ring he slides the movable half of the lens until the mast head has come down to the water level; he then reads off the range—provided he knows the ship and the height of the mast or funnel observed. The new prismatic binocular (apparent field of 55 deg.) remains permanently in optical adjustment. It is the invention of Mr. H. Dennis Taylor, the inventor of the Cooke lens, and its peculiarity is that the prisms are placed outside the telescope tubes; perfect definition is obtained all over the field.

Of optical interest in the exhibits of Messrs. Taylor, Taylor and Hobson, of Leicester, are the well-known Cooke lenses which the firm manufactures, and the Aviar lenses (10½ in.) for aerial photography, which certainly give a remarkably uniform definition all over the 5-in. by 4-in. plates in enlarged views. The other exhibits are an engraving machine, a dividing head, screw-thread chasers, measuring machines, &c. Messrs. W. Watson and Sons, of 313, High Holborn, draw particular attention to their microscopes, binoculars, range-finders and other instruments to be used in the fight against submarines and warfare generally. The combined optical square and hand level of Messrs. E. R. Watts and Son, of 123, Camberwell-road, S.E.5, is a pocket instrument weighing 4 oz. It consists of a rectangular prism, which reflects a constant angle of 90 deg. correct within a minute of arc, and is mounted on a small platform; the upper surface of the glass is covered with sheet metal. In laying out an exact rectangle from a base AB, the handle of the lens is fixed vertically at A, and a plummet or staff fixed at B if necessary; an assistant moves the staff near the third point C to be determined, until the observer at A sees the reflected image of B in coincidence with the direct image of C, visible above the lens; then BAC will be a right angle; the fourth point corner of the rectangle is similarly found. A plumb line is attached to the lens; to use the instrument as a level, the handle is held horizontally on some support, and will be exactly horizontal when the line and its image are at right angles to one another; by looking through the sight hole next to the prism, a distant point can be found, which is level with the sight hole. The improved mining theodolites of Messrs. Watts also deserve notice.

The "artificial-daylight lantern" of Mr. Lionel Pearce, of Platts, near Stourbridge, is a simple device intended to enable people to examine coloured articles (fabrics, pictures, microscopic preparations, &c.), which are placed in the lantern, in artificial daylight though the room is illuminated by gas or electricity. The lantern is a little metal box, 9 in. by 7 in., partly open in front, which holds in its upper covered portion a tungsten lamp; underneath the lamp is a glass screen, colourless, but impregnated with constituents so as to correct the light falling through the screen upon the object which is placed at the bottom of the box. In order to make it easier for the eye to accommodate itself to the daylight, four coloured (red, green, green, orange) windows are provided in the front of the box. The fine collection of graticules (grainless and filmless photography), and the platinised mirrors of Messrs. Rheinberg, of 57 to 60, Holborn Viaduct, E.C. 1, mentioned last year, is now arranged as adapted to peace work. The application of graticules to the measurement of the bore of glass capilliaries is an interesting novelty. The tube is cut across and so placed in the V-slot of a wooden ledge that the cut end bears against a glass disc. The image of the bore is then seen magnified about 30 times through the eyepiece of a small microscope against a field consisting of rectangles. The lengths of the sides of the rectangles are such that the short side corresponds to the minimum size of bore which would be allowed to pass, whereas the longer side corresponds to the maximum permissible diameter. The observer will at once see whether the tube, which may be 24 in. in length to fit the ordinary ledge of the apparatus, falls within the tolerances.

Radium.—The exhibits of radium and compounds of Mr. F. Harrison Glew, of 156, Clapham-road, S.W.9, comprise gun-sights and other novelties, now shown for the first time. The sights for rifles and guns are only intended for night service, and are then turned upward, being pressed down forward by a spring, as long as daylight is available. The luminous line is formed by a small glass tube, about 1 cm. high, more than 1 mm. in diameter, which is sealed above and contains a mixture of radium and zinc sulphide. Mr. Glew has supplied as many as 11,000 of these tubes per day, and the 400 tubes which he exhibits were made two years ago. The radium percentage is 0·4 milligram (calculated as bromide) per 1,000 mg. of zinc sulphide; the sulphide should not be pure, but the problem of the nature of the active impurity is not solved yet. The radium is recovered from old mixtures, and Mr. Glew noticed in these operations the presence of specks of an insoluble impurity, probably mica. A little disc or strip of mica placed over the mixture in a capsule bulges up, apparently because helium (α-rays) accumulate under the mica, the exposed surface of which corrodes and becomes iridescent, green or pink. A soda glass in which the compound is kept, turns amethyst colour; a potash glass, brownish; the little glass tubes for sights are hence preferably made of soda glass. The scintilloscope of his is a kind of spinthariscope serving for the detection of radium in ores; a very lively scintillation can be seen. The light of a glow worm, Mr. Glew has found to be stronger than that of the Admiralty compound of the strength above mentioned. As regards the penetrating power of radium rays, i.e., the most penetrating γ-rays, Mr. Glew shows a photograph darkened by rays penetrating through 15 in. of pig-iron, and performs some interesting and simple experiments.

Lens-Making Machinery.—In the new two-spindle universal lens-surfacing machines of Messrs. Bryant, Symons and Co., of 320, St. John's-street, E.C.1, one spindle is arranged for polishing spherical and plane lenses, and the other for polishing cylinder and toric lenses, both working automatically. The precision lens centring and edge-grinding machine also embodies some new features. Their screw-correcting lathe cuts screws for gauges, the over-all length error in 8 in. being within 0·0004 in., and the periodic error within 0·0001 in. The grinding and polishing machine of Mr. A. J. Greenaway, 38 to 40, Great College-street, N.W.1, is an automatic, six-spindle eye-piece grinding and polishing machine, occupying 6½ ft. by 3 ft. floor space and weighing 12¼ cwt.

Measuring and Testing Machines.—Turning finally to measuring machines, notice of some of which was held over in expectation of further information, we have to mention, in the first instance, Professor E. G. Coker's polariscope for stress studies of models. Professor Coker has set up a working apparatus in which celluloid specimens are put under stress, the load being applied and released by eccentrics secured to a shaft, which is operated by a motor; the polariscope gives circularly-polarised light by reflection from a black glass plate and subsequent transmission of the light through quarter-wave plates of mica. Messrs. G. Cussons and Co., of Lower Broughton, Manchester, exhibit a collection of the new projection apparatus and screw-measuring machines of the National Physical Laboratory, together with a floating micrometer of their own, capable of measuring screws, 18 in. long, 2½ in. diameter, within 0·0002 in. The rotary dividing machine of Messrs. Endacott, of 58, Hatton-garden, who also contribute to the optical exhibits, is a revolving disc of gunmetal (weighing 1 cwt.), cut on its circumference with 720 teeth, and subdivided into minutes and seconds of arc, by means of a tangential micrometer screw; articles of 17 in. diameter can be divided directly, and the cradle cutting arm can inscribe horizontally, vertically or at any angle.

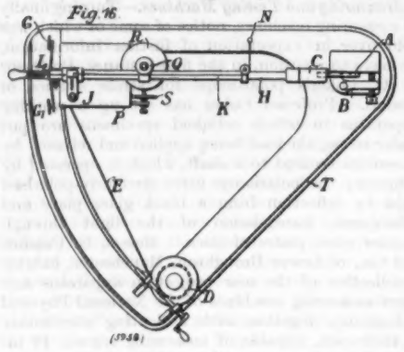
The Eden-Foster repeated impact-testing machine of the Foster Instrument Company, Letchworth, is of the Stanton type. The cylindrical specimen is provided with a round notch and supported horizontally in hard-steel bushes to receive the blow of the trip, a vertical cylinder weighing 5 lb. or 2 lb., which is dropped through heights ranging from 1 in. to 4½ in.; after each blow, the test piece is automatically turned through 180 deg. about its longitudinal axis.

The J. C. W. Humfrey autograph notched-bar testing machine of Messrs. Foster records the action of a specimen when breaking down under bending stress. Figs. 15 and 16, on page 154, represent the machine in plan and elevation. The framing of the instrument is a casting T of sector shape. The specimen A is selected as a bar of 10 mm. square section and conveniently provided with several notches so that several consecutive tests can be made on the same test piece, and the results can be averaged. The specimen is gripped in the vice B, the jaw-ends of the vice being in line with the notch in question. The socket C is pushed over the projecting end of A, fitting fairly close. A bending stress is applied to C and A by the intermediation of the winch D and the wire E, which is attached to the outer end of the spring steel bar F, which is provided with two rollers G and G^1; the inner end of F is firmly fixed to the socket C, which further carries a rigid bar (brass tube) H. This bar H is not subject to any bending moment, but it moves through the same angle as C, whilst the spring F is deflected by an amount corresponding to the bending moment. On H slides the pen J, the position of J being determined by the two

cords or wires K and L, which the spiral spring M keeps taut. One end of K is attached to a post N, and as H moves when the test-piece is bent, K will draw the pen J to the right. The pen marks upon a calibrated chart P. If the specimen offered no resistance whatever to the bending force, J would draw a horizontal line on the chart, proportional in length to the angle through which the specimen has been bent. If the test-piece were infinitely rigid, there would be no bending, and a vertical line would be drawn, its length or height representing the magnitude of the bending moment. As resistance is offered, the pen draws a graph indicating the relation between the bending moment applied and the angle of bending. Brittle and tough, ductile materials will hence give different records, and it has been found that the proper heat treatment to be given to a steel can be determined by a series of these tests. The total energy absorbed in fracture can

Fig 15

Fig 16



further be calculated from the graph. The machine can also be fitted with an integrating device, as our diagrams illustrate. The wire K passes over a pulley Q, which is attached to a spindle having at its lower end a friction disc R; R partakes in the movement of the pen to the right and rests with its lower surface on a friction wheel (not shown), the spindle of which is carried, together with the chart plate, on the spring bar F. With zero bending moment, the friction wheel is at the centre of the friction disc; as bending sets in, the wheel travels to the circumference of the disc and is rotated, the rotation being proportional to the product of bending moment and angle of bending. This device, therefore, integrates the total energy absorbed in breaking the specimen. The index disc S, mounted upon the outer end of the spindle carrying the friction wheel, is calibrated to read directly in foot-pounds.

The measuring machine and comparator of Messrs. Reid Brothers, 12, Wharf-road, City-road, N.1, at once tells an unskilled man whether a rod or plate is of the correct thickness. The specimen is placed between the anvil and the "hammer," a vertical rod to which are attached a disc-bearing and, higher up, a micrometer screw, and further a pointer which glides in the slot of a vertical scale; the rod roughly resembles a T in section. The bearing is supported by a horizontal frame of the shape of an open angle; at the end of the one arm is a lamp, at the other a vertical scale on which the reflected light spot is watched. The beam falls from the lamp through a collimator on to a small mirror which is tilted by the weight of the hammer; the mirror reflects the beam on to a fixed mirror, from which it goes back to the movable mirror and to the final scale. The light hence describes a W path between the two mirrors, which can be adjusted for any desired magnification. The characteristic feature of the machine is the mounting of the movable mirror in the bearing; the mirror movement is controlled by two small flat springs, which are bent by the weight of the hammer to an amount depending upon the depth to which the hammer is able to descend when resting with its foot on the specimen.

Engineering Exhibits.—To the notices of exhibits of an engineering character dealt with in our previous articles we are now able to make some additions. Messrs. Vickers, Limited, of Broadway, Westminster, S.W. 1, have a large stand facing the entrance showing examples of many of their own products and those of associated firms. With most of these products, such as duralumin, twisted drills of vanadium steel, adjustable reamers, solid reamers, milling cutters and other small tools made from tungsten alloy high speed steel, engineers are quite familiar, and the quick-change drill chucks shown, which enable drills and other similar tools to be changed without stopping the machine, have already been illustrated and described in our columns (see Engineering, vol. xcv, p. 806). The pocket hardness comparator shown is, however, of more recent introduction. This is an instrument for ascertaining roughly the Brinell hardness of any article in steel, or other metal, without the aid of a microscope, or any measuring device, and the results obtained, on large or small pieces, are quite independent of the nature of the support or foundation. Another advantage is that a test can be made on a surface at any angle with the horizontal. Briefly, the instrument comprises a cylindrical steel holder with one end conical, containing a hardened steel ball, 1 cm. in diameter, part of which projects through the other end. A rectangular slot is pierced diametrically through the cylindrical part of the holder, and through this slot is inserted one of a set of ten steel bars of standard hardness numbers. The standard bar bears on the steel ball, and is kept in contact with it by a stiff spring. In making a test a standard bar is selected with a hardness number approximating, as nearly as can be judged, to that of the object to be tested. This bar is inserted in the ball holder, and the instrument, handled by the bar, is placed with the ball in contact with the surface to be tested, which surface has previously been filed smooth. A light blow is then delivered with a hammer on to the end of the ball holder, and this causes an impression of the ball to be made on the work and also on the standard bar. On removing the latter the impression on it is compared with that on the work, and in this way it is quite easy to judge by eye whether the bar is harder or softer than the work. If the difference is considerable another test bar would be selected, and the process repeated, until the two impressions are approximately equal. It will be obvious from the foregoing description that, in order to determine the hardness of the work with absolute accuracy, a test bar would be required of exactly the same hardness, but for practical purposes it is generally sufficient to use two standard bars which represent the limits of the specification to be worked to. The instrument is supplied in a leather case with ten standard test bars having Brinell numbers ranging from 150 to 550. A large number of tests can be made with each bar using all four sides, and spare bars can be supplied when the whole surface of any of the bars has been used. Another recent production of the firm is a sewing machine for domestic use, of the vibrating shuttle type. It is made for hand or treadle working, and includes a number of improvements. Of these we may mention the reversible feed which enables the operator to sew backwards or forwards without removing the work. Other exhibits at this stand include a section of the Wolseley "Viper" aeroplane engine, plug screw gauges, railway tyres and axles, locomotive crank axles, drop forgings, alloy steels for aeroplane and motor car construction, high tensile solid drawn steel tubing, tool steels, porcelain insulators, electrical heating and cooking apparatus, electrical fans, and magnetos. The latter are made by the British Lighting and Ignition Company, Limited, of which firm Messrs. Vickers are the proprietors, and they are sold under the trade name "B.L.I.C." A large number of these magnetos in types and sizes suitable for motor cycles, motor cars, aeroplanes and large stationary gas engines are on view. Another exhibit of this firm, viz., the "Restucci" tube cleaners for boiler and condenser tubes, we hope to illustrate and describe fully in a future issue.

The Budenberg Gauge Company, Limited, of Broadheath, near Manchester, show a case containing a selection of their well-known pressure gauges of the Bourdon, Schäffer, and steel-tube types, as well as a number of recording pressure gauges, portable gauge testers, indicating and recording tachometers, and other instruments. Steel-tube thermometers, of the dial-indicating and recording types, are also exhibited. These thermometers are made with rigid stems, or with flexible tubing connecting the steel bulb with the indicating part, and, as usually supplied, are suitable for temperatures up to 950 deg. Fahr. A special pattern can, however, be used for temperatures up to 1,100 deg. Fahr. One special thermometer of this type, used on locomotives for measuring the temperature of superheated steam, is fitted with double flexible tubing, so arranged that changes of temperature in the connecting tubes do not affect the readings of the instrument. One of the firm's "Perfect" restarting injectors is also shown.

Messrs. Stothert and Pitt, Limited, of Newark Works, Bath, have a small stand showing three models of their recent productions. One of these is a model of a set of Toplis patent electrically-operated davits, for use on large passenger ships. The boats, which are placed side by side on the boat deck, are lifted from a pair of arms pivoted on the centre line of the ship, and so arranged that the boats can be put into the water on either side of the vessel. Another model shown is one of the Toplis patent horizontal luffing cranes for shipbuilding yards, but, as we illustrated and described this crane in our issue of February 14 last, on page 208, we must refer our readers to this article for full particulars. The one other exhibit at this stand is a model of the Feuerheerd rotary pump, which can also be used as a prime mover when supplied with fluid under pressure. This appliance we intend to deal with fully in an early issue, so that we need do no more than mention it here.

A new type of two-cycle engine, which is the invention of Mr. J. Davidson, and can be arranged to run on petrol, paraffin, or town gas, is shown by the Record Engineering Company, Limited, of Tutbury, Burton-on-Trent. These engines are built in sizes ranging from 1 to 100 horse-power, and are suitable for all kinds of industrial work, as well as for driving electric generators and motor boats. They are claimed to be absolutely silent in running and to have an efficiency equal to any four-cycle engine. The engine exhibited, which is of the 10 horse-power size, has two vertical cylinders, over each of which is mounted a double-acting pump cylinder of about half the volume of the working cylinder. The pump pistons are connected to the working pistons by tubular extensions of the latter and by short piston rods, and the arrangements are such that the explosive charge drawn in on the underside of the pump piston during the upward stroke, is forced into the working cylinder at the end of the downward stroke through ports uncovered by the extension of the working piston. At the same time a charge from the upper end of the other pump cylinder is delivered into the lower end of the first-mentioned pump, and thence into the working cylinder, driving out the products of combustion of the previous explosion and completely filling the cylinder. The charge is compressed by the upstroke of the working piston, fired in the usual way, and exhausted through ports uncovered by the working piston at the end of its stroke. The flow of gas into, and between, the two pump cylinders is controlled by a single piston valve placed between them, and operated by an eccentric on the main crank-shaft. This valve, it will be noticed, is not subjected to high temperatures. Another advantage claimed for these engines is that the crank-case is not used for compressing the explosive mixture, so that there is no possibility of the fuel oil or spirit becoming mixed with the lubricating oil. In a recent endurance test, a 50 horse-power Vee-type engine of this design was run continuously, day and night, for six days without any adjustment or attention other than that required to maintain the supply of fuel and lubricating oil.

The Exhibition is to be kept open on Bank Holiday, and to be closed the day following, August 5.

INDUSTRIAL NOTES.

VARIOUS conferences have been held dealing with the coal crisis in Yorkshire, following which official statements have been issued.

The Prime Minister met representatives of the Miners' Federation of Great Britain at 10, Downing-street, on Thursday, July 24, to discuss the question of the adjustment of piece rates in the coalfields in view of the reduction of hours consequent upon the Sankey interim report. Mr. Smillie submitted the case for the miners as set forth in the following Keswick Conference resolution:—

"This conference decides that the maximum figure to be accepted in any given district for the reduction of 1 hour per working shift shall be 14·3 per cent., with a proportionate increase for every fractional part of an hour reduction, provided that such increase in rates shall not mean an increase in actual wages."

After discussion, the Prime Minister, on behalf of the Government, submitted the following formula for the consideration of the federation:—

"Accepting and acting on the basis laid down in Mr. Justice Sankey's interim report, that the reduction in output will be less than 10 per cent., the Government is prepared to see that the piece workers will not suffer any loss of earnings. The piece rates will, therefore, be increased by an amount which, on the average, will be thought necessary to correspond with a 10 per cent. reduction in output."

On Friday last, a conference with the Miners' Executive was held at Downing-street, after which the following statement was issued:—

"The miners' representatives met the Prime Minister and members of the Government at the request of the federation. They put forward approximate estimates of how the formula proposed by the Government for the new piece rates would work out in the different districts in the light of the variations in reduction of working time consequent on the introduction of the 7-hour shifts. The conference was adjourned in order to allow the Government to check these estimates, and will meet again at Downing-street at 4 o'clock.

"The Prime Minister presided over the conference, and there were also present Sir Evan Jones (Coal Controller), Sir Robert Horne (Minister of Labour), Sir Richard Redmayne (Chief Inspector of Mines), Sir Auckland Geddes (President of the Board of Trade), Sir David Shackleton (Permanent Secretary to the Ministry of Labour), and Sir Maurice Hankey. The miners' representatives included Mr. Robert Smillie, Mr. Frank Hodges, Mr. Vernon Hartshorn, M.P., Mr. Robson, Mr. Straker, Mr. Frank Hall, and Mr. G. Barker."

The conference was resumed at 4 p.m. on the same day, when the following statement was made public:—

"After consultation between the Government and the Executive of the Miners' Federation an agreement has been reached that the principle laid down by the Government yesterday will be adopted, namely:

"Accepting and acting on the basis laid down in Mr. Justice Sankey's interim report that the reduction in output will be less than 10 per cent., the Government is prepared to see that the piece workers will not suffer any loss of earnings. Piece rates will, therefore, be increased by an amount which on the average will be that necessary to correspond with a 10 per cent. reduction in output.

"In order to carry out this it is necessary to fix a definite average reduction in working time resulting from the introduction of a 7-hour day, and after examination of the figures it has been decided to accept 47 mintues as the basis for this calculation."

Last Tuesday, Sir Robert Horne, Minister of Labour, wrote to Mr. Frank Hodges, Secretary of the Miners' Federation, stating that, although an agreement was arrived at last week between the Government and the federation, the Yorkshire miners were still on strike. The Government, Sir Robert added, was anxious to know what steps Mr. Hodges was taking in the direction of inducing the men to return to work, and what prospects he entertained of the strike being brought to an end speedily.

Mr. Hodges immediately replied that the federation had communicated their decision to all districts, and enclosed copies of the circulars which were also sent to all districts. The first circular is as follows:—

"The following is a copy of an official statement issued by my Executive Committee for the benefit of our members. I am sending it to you officially in order that you may have it upon your records:—

"The Executive Committee and the Government have come to an agreement on the Government's formula as to the increased rates for piece workers to compensate for the reduction in the working day consequent upon the Sankey report.

"The effect of the agreement is to obtain 14·2 per cent. increase in rates where the reduction in the working day is 1 hour. Where a lesser reduction in the working day takes place a proportionate increase in rates will be paid for such reduction.

"In view of the above agreement the Executive Committee strongly urge upon all the districts affiliated to the federation loyally to carry out this decision, and where men are now idle in consequence of this dispute the committee earnestly appeal to them to resume work.

(Signed) "FRANK HODGES, Secretary."

The further communication is as follows:—

"In order to give effect to the agreement arrived at between the Government and my Executive Committee, the Coal Controller has been instructed to forward to the secretaries of the various coal associations the Government formula, which now embodies the agreement arrived at.

"You will therefore now be in a position to complete your negotiations for the proper increase in rates in your district on the basis of the agreement.

"The formula will be as follows: 47 minutes average reduction over the whole country; 10 per cent. reduction in output; 11·1 per cent. increase in wages. (*a*) Assuming the reduction in hours in district A is 1 hour, the increase in piece work rates in that district would be 11·1 per cent. × 60 minutes ÷ 47 minutes—say, 14·2 per cent. (*b*) Assuming the reduction in hours in district B is 10 minutes, the increase in piece work in that district would be 11·1 per cent. × 10 minutes ÷ 47 minutes—say, 2·36 per cent.

(Signed) "FRANK HODGES, Secretary.

At the time of writing we are informed that the Yorkshire miners refuse to accept the terms which, as has been seen, were agreed upon between the Government and the Miners' Federation.

A dispute which had arisen at the Liverpool Docks and had lasted for about 10 days, was settled early in the week. The following are the main terms of settlement arrived at:—

The vessels comprising the Board's floating plant must be recognised as ships, and the men engaged thereon as seamen. The negotiations in future are to be dealt with by a committee of the Dock Board's representatives and of the men's representatives. The wages of seamen and firemen shall be the coasting rates, less the 10*s.* war risk allowance. All officers, seamen and firemen engaged in navigation will be allowed a spell ashore at week ends extending over four tides. The men and officers in the sand pump dredgers will revert to the weekly system of working, but this change is conditional upon the men turning up regularly on Mondays to put to sea. Officers will receive an advance in wages of approximately 10 per cent. The men on the floating cranes will work a 47-hour week and the usual rates of overtime will be paid. The question of the working of the general hoppers and some of the smaller craft was referred to the committee to work out details. For general hoppers there will be a double shift of 24 hours, each shift will be arranged. The bucket dredgers will work 9-hour watches, 1 hour being allowed for meals. The allowances to men on lightships are increased. The survey ships will work from 7 a.m. to 5 p.m., but half the crew will go on board at 8 o'clock, and overtime will be paid for time when the ships are actually working in excess of these hours.

A few minor points are to be dealt with by the joint committee which is to meet at the Dock Board Offices.

The increase in pay will be retrospective, starting from the first pay day after May 15.

A meeting of shipbuilding and engineering employers and representatives of shipyard, engine shop and foundry trades unions was held last week in London to consider the application of the workers for a further reduction of hours to 44 a week.

The employers separately considered the men's case, and on resuming Sir George Carter, president of the Shipbuilding Employers' Federation, and Sir Allan Smith, chairman of the Management Committee of the Engineering Employers' Federation, stated that the output was not being maintained under the 47-hours week; in fact, it had lessened since 1913. Whether the decline was wholly or only partially due to the shortened hours was possibly obscure, and they suggested that the present application be either withdrawn or suspended for two years to permit of a thorough investigation of the matter.

Mr. Brownlie, chairman of the Executive Council of the Amalgamated Society of Engineers, in reply, said that his committee had no power to suspend or withdraw the application. That was a matter for determination by the conference who had appointed it.

Mr. John Wyndham Beynon, presiding on Thursday, July 24, at the fifty-second ordinary general meeting of the Ebbw Vale Steel, Iron and Coal Company, Limited, said that the directors had decided to extend an invitation to one of the great trade unions to nominate one of their number to occupy a seat on the Board of the company. He regretted to state that this invitation to labour had been refused. In that, he was somewhat surprised and considerably disappointed. He added that if labour seeks to control industry, then labour should be prepared to serve its apprenticeship side by side with men who have made it their lifelong study. They had hoped that the presence of labour on the Board would have done much to dispel that atmosphere of suspicion and mistrust which unhappily existed in the minds of the working classes. They had hoped that by so dispelling that atmosphere it might have been possible to have obviated many of those irregular strikes which take place with so monotonous a regularity.

On the question of reduction in coal output, Mr. Beynon said there was, particularly in South Wales, a disinclination on the part of many men to earn wages which would bring them under the income-tax returns, and they openly state that they have no intention of earning wages on which they will have to pay income-tax. It sounded incredible that a man would deliberately deny himself 20*s.* worth of wages because on that he would pay under 2*s.* to the Government, but such unhappily was the case.

Speaking at the thirty-first annual ordinary general meeting of Messrs. Greenwood and Batley, Limited, Colonel O. C. Armstrong, D.S.O., the chairman, said he knew their workpeople read the company's annual report, and he would appeal to them calmly to consider how very closely their own future prosperity was bound up with the success or failure of the industry they served. There could be no question of the supremacy of the British engineer, but under modern conditions a mere percentage value was placed on such supremacy, and if this were exceeded the orders for plant or machines were apt to go to other countries. So long as the war lasted the men responded splendidly to all demands made on them, and he was sure everyone appreciated that the strain had told on them as it had on others. Now, however, it behoved us all to pull together and fight hard to regain and retain our supreme position among the industrial nations. He was glad to say that the company's order book was full. They had enough work to employ every available hand for the next twelve months, always provided that they could produce within reasonable economic limits and were not hampered by periodical labour disturbances.

In the course of his speech at the fifth annual general meeting of the Mond Nickel Company, Limited, the chairman, Mr. Robert Mond, J.P., gave the following figures of increased costs. He stated that "in common with other manufacturing concerns, our cost of production has been immensely increased in the course of the war. In Canada the cost of mining and of the production of matte has practically doubled, and at our works in South Wales the wages of our process men have risen by from 180 per cent. to 213 per cent.; the wages of the tradesmen on shift work have increased by 187 per cent. and of the day labourers by 142 per cent. The cost of coal has more than doubled, and that of sulphuric acid, which, next to coal, is our most important raw material, has increased by more than 170 per cent. Timber has increased by 400 per cent., steelwork by 180 per cent., bags by 190 per cent., and casks by 170 per cent. In spite of this large increase in the cost of production, we have succeeded in selling our nickel during this war to the Government at only comparatively slight advances over pre-war price. This we were able to do as we realised much higher prices for our copper sulphate in the export markets of the world, where the price was regulated by the cost of copper. At home, the Board of Agriculture, in consultation with the manufacturers, fixed a much lower price for copper sulphate than that ruling abroad, by which the farmers in this country benefited. I might also mention that the platinum and palladium obtained from the residues of our refining process, which were refined for us by one of the leading metallurgical firms, helped to supply the enormous war demand for these precious metals."

IONISATION OF GASES DURING CHEMICAL REACTIONS.—Although it is often suggested that the chemical interaction between two gases should be accompanied by an ionisation of the gases, there is no conclusive proof of any such ionisation. In recent experiments Alexandre Pinkus (*Helvetica Chimica Acta*, vol. i, pages 141 to 145, October 1, 1918) seemed to obtain evidence of an ionisation; but he himself admits the necessity of further proof. He mixed nitric oxide with either oxygen or chlorine in a large glass globe, and placed electrodes of iridio-platinum on the walls joined to an electrometer, the discharge of which would indicate ionisation. In the case of nitric oxide and oxygen there was certainly no ionisation. Nor was there with nitric oxide and chlorine, except when the chlorine was in excess; in that case the chloro hyponitric acid $NOCl_2$ was probably formed as intermediate product.

THE VIRIAL PROBLEM OF CLAUSIUS.

To the Editor of Engineering.

Sir,—In the errata of the memoir of the late Lord Rayleigh, page 48 of your issue of the 11th inst., reference is made to the *virial* problem of Clausius. I should be much obliged if you would kindly tell me the meaning of this name, which I am unable to find in any dictionary, scientific or otherwise.

Yours faithfully,

July 25, 1919. Inquirer.

[The *virial* problem concerns the energy relations in systems in motion, the parts of which are themselves capable of motion as the particles of a fluid or gas. The kinetic energy of a particle of mass m moving at velocity v is $\frac{1}{2} m v^2$; and the kinetic energy of the system is the sum of these energies $\Sigma (\frac{1}{2} m v^2)$. When the motion of a material system is such that the time-average of the quantity $\Sigma (m x^2)$—where x refers to the distance from one of the three axes—remains constant, the system is said to be in stationary motion; the movements of the planets about the Sun and most periodic motions, which are restricted as to range and velocity and alternate in direction, are stationary in this sense. When some force or stress, attraction or repulsion, acts between two points of the system, half the product of this stress into the distance between the two points is called the "virial" of this stress. The virial of a system is the sum of all virials of the stresses in the system. If the whole system be further subjected to external stress (a gas to pressure, *e.g.*), then a further virial $= \frac{3}{2} p V$ will be set up where p is the pressure and V the volume of the vessel.

The theorem of Clausius (important for the kinetic theory of gases, of which Clausius is one of the originators, and for dynamics in general) now states: In a material system in stationary motion the time-average of the kinetic energy is equal to the time-average of the virial.—Ed. E.]

CENTRIFUGAL FORCE.

To the Editor of Engineering.

Sir,—In Engineering of July 18, page 91, the reviewer of "Elements of Graphic Dynamics," at foot of second column, says that the author might have said that there is no such force as "centrifugal force."

I venture to assert that the use of this expression is perfectly correct, and that the original arguments against its use no longer apply because the ideas that gave rise to confusion and error on this subject belong to a generation which is past.

The term "centrifugal force" is now merely a baptismal appellation, and its meaning has to be sought in the analysis of the particular circumstances involved.

The expression is used by such a great authority as Sir George Darwin, who, in his book on the Tides, dated 1911, uses it freely, and on page 100 occurs the following: "The total of the centrifugal force acting on the whole earth must be just such as to balance the total of the centripetal forces due to the moon's attraction."

I send you this letter because I believe that your reviewer's remarks will tend to confuse the student, and I know that your journal is looked to for guidance in scientific matters by students of all ages, amongst whom I count myself.

Yours truly,

"Surveyor."

Leeds, July 22, 1919.

[I am sorry that the author of the above letter should have misconstrued my remark concerning "centrifugal force." I understood that the author of the book reviewed was endeavouring to instil correct methods of thinking, and fighting a common error, more generally entertained than "Surveyor" appears to be aware, and I was very heartily with him. The comment to which "Surveyor" takes exception would perhaps have been more clearly expressed, had I given it the form "and he might have written even more emphatically." I cannot agree with "Surveyor" when he states that "the ideas that give rise to confusion and error on this subject belong to a generation which is past." I would it were so, but my experience teaches me otherwise.—The Writer of the Review.]

THE MECHANICS OF METALS.

To the Editor of Engineering.

Sir,—Roger Bacon begins his "Opus Majus" with an exposition of the principal impediments to the progress of knowledge, and the effect of these impediments is clearly discernible in the history of metallurgy and engineering. The mechanics of metals forms a large part of both these sciences and a review of our knowledge may be salutary, as a clear and unbiassed perception of present deficiencies is essential to the future development of engineering.

In the first place, it may be recorded that there is no satisfactory theory of the constitution of solids—equivalent to the kinetic theory of gases—whereby the various properties can be connected with one another and with the prevailing temperature and pressure. In the absence of such a theory it is convenient to group mechanical qualities in accordance with industrial practice regarding their measurement, rather than on the necessarily provisional basis of whether they are fundamental, or arise from the conjunction of two or more fundamental properties.

It appears to be the practice of one of the most advanced metallurgical laboratories in the Kingdom to judge all the diverse utilities, perfections and imperfections of a metal on the evidence of microscopical examination aided by a number of highly developed minor arts, chemical analysis, and some 20 different mechanical tests. In less important laboratories a smaller number of discriminants are applied, and the distinctions drawn are correspondingly less refined.

Whether the number of important fundamental mechanical qualities is as many as 20 is uncertain; but, if there are no more, then 20 different experiments will suffice to determine them all, provided the experiments are not altogether unaffected by any of the qualities, and may be relied upon to give the same results when they are repeated with the same material.

A few of the recognised properties of metals will now be briefly considered, although within the limits of a short note it is impossible to enumerate them all or to do justice to any.

Density, Elasticity, &c.—It seems to be proved that the various chemically distinct bodies are made up of separable stiff elastic units called molecules, and that the mechanical properties of solids arise from the pattern in which the molecules are arranged, and from the particular balance which subsists between their mutual attraction and the effective repulsion due to continual thermal impacts. Whether this view be accepted or not there can be no doubt that density, which measures the mean spacing of the molecules, is a primary factor of consistency, and must be given first place in the list of important mechanical qualities.

The elasticity of ordinary metals is best considered in terms of the two stresses which represent elastic resistance to alteration of shape and to alteration of size. The ratio of these stresses, which may be called "N," determines the distribution of stress and strain, and therefore exercises a great influence on the prospects of a piece of metal being broken or permanently distorted by given forces, although "N" is in no sense a strength. Two metals in which "N" is the same behave similarly when forces are slowly applied; if, in addition, the densities are in the ratio of corresponding elasticities the metals are dynamically similar. The number "N" represents a property second only in importance to density, but its claims to recognition have not yet resulted in its being given a name.

It is difficult to believe that accurate measurement of the density of samples does not form part of the daily routine of every testing laboratory, but the evidence available to the public makes no other conclusion possible. All that is known of the elastic constants and the number "N" is their approximate magnitude, and the fact that they vary greatly with slight changes in chemical composition, and with the mechanical and heat treatments to which the metal has been subjected. The character of the variations does not seem to have been studied at all.

Strength, Hardness, &c.—Qualities in the preceding group are sharply defined, but are not customarily measured. The present group is comprised of qualities which are measured but are not defined.

The word "strength" is used with two entirely different meanings, but the distinction is well understood and no confusion arises on this score. In its more important sense "strength" implies the persistence of elasticity under considerable stresses and stress differences. The measure of strength is the stress system which will produce a given small permanent angular distortion in a given time; but there is no accepted convention as to the angle and time which should be adopted, so experimental determinations are robbed of all their comparative value and precision. "Strength" is not a single quantity but may be represented graphically by a surface; the shape of this surface is still completely unknown, although Hertz called attention to its importance nearly 40 years ago.

In commercial specifications "strength" has another meaning, and must be regarded, not as a property of a metal, but as the result of a procedure. The details are worth considering, as their baffling complexity is typical of so many of the tests which are now relied on.

The material is first radically altered by an uncertain mechanical process; a piece of the altered material of unknown dimensions is broken at an unknown speed, and the force acting when rupture occurs is the "ultimate tensile strength." The connection between the force arrived at in this way and the scantlings of a bridge, for example, is not very evident: the unseen link is the "factor of safety," a large part of which represents professional distrust in current tests.

Hertz and Clerk Maxwell agree in considering hardness as a strength, but differ as to what particular strength it should be; other authorities do not regard hardness as a strength at all. Many methods have been elaborated for measuring the property, and several instruments for this purpose are produced commercially and used in hundreds of laboratories. Materials which give the same reading with any one of these instruments are possibly the same; those which give different readings are certainly different. The tests give a simple criterion of uniformity which is valuable, but it cannot be expected that measurements with different types of instrument should be concordant.

Brittleness, Toughness, &c.—Brittleness and toughness are typical of very real and important qualities which are neither measured nor defined. Brittleness is perhaps best regarded as a character without dimensions, and the number "N" may be found to represent what is implied by the word. Toughness suggests something more than a strength, and its definition is preferably left open until the phenomena of dilatancy have been investigated.

Dilatancy.—Professor Osborne Reynolds published his discovery of dilatancy in 1885, and on it based a theory of the structure of the universe which accounts for the observed properties of inter-stellar space, and for gravitation and many of the chemical and electrical properties of matter.

The discovery is applicable to a wide range of subjects, and clearly interprets many isolated observations whose causes would otherwise be obscure. The "cry" of tin; the low density of the earth's crust at the foot of the Himalayas; the hardening of metals by strain, and the slow deterioration of railway axles are all satisfactorily explained. A very little experimental development of the subject promises to yield a valuable theory of the constitution of metals, which may connect mechanical with other properties and cannot fail to have a great influence upon the future of metallurgy and engineering.

In 34 years no single determination of the elements of dilatancy appears to have been made, and it may be well to emphasise that what is here neglected is not a recondite department of abstract physics: it is a whole province of nature, and a province of the greatest industrial importance.

The limits of elasticity are the beginnings of dilatancy, and possibly investigators are well advised to stop at this point. Shortly after he finished the "Opus Majus" Bacon was thrown into prison, *propter novitates suspectas*; he was kept in confinement for 14 years, and died soon after his release. Seven centuries have passed, but the Dark Continent may still be dangerous!

I am, yours truly,

J. Innes.

51, Victoria-avenue, Whitley Bay,
Northumberland.

DEFIBRATING COTTON SEED.

To the Editor of Engineering.

Sir,—My attention has just been called to a note in your issue of July 25, in which you refer to the cotton-seed-defibrating machine exhibited at the British Scientific Products Exhibition as a *working model*. I can quite understand that the small size of this machine should have given your representative such an impression, but, as a matter of fact, exhaustive research and trial during the last three years has shown that no useful purpose, either as regards efficiency or economy, is served by making the machine any larger.

The reference to this machine in your columns as a "working model" has already given rise to some misapprehension, and I should be very glad if you could find space for the insertion of these few lines in your next issue.

Yours faithfully,

Ed. C. de Segundo.

Dashwood House, New Broad-street, London, E.C.,
July 30, 1919.

The Department of Dyes.—Sir Evan Jones, Bart., M.P., has found it necessary to resign his position as Commissioner of Dyes in consequence of the heavy duties attaching to the post of Controller of the Coal Mines Department. In future, therefore, all communications referring to dyes should be addressed to the Assistant Secretary, Industries and Manufactures Department, Board of Trade, Gwydyr House, Whitehall, London, S.W. 1.

Personal.—With the rapid growth of their business, especially in connection with concrete housing schemes and reconstruction work generally, Winget, Limited, have moved their North of England office at Middlesbrough, to 27, Wilson-street, opposite the Royal Exchange. Here they have their show rooms, where their concrete block and slab-making machinery, and concrete chain-spade mixer, may be seen in operation.—Owing to continued ill-health, Mr. Arthur Gulston has resigned the position of superintendent engineer of the Walker shipyard of Sir W. G. Armstrong, Whitworth and Co., Limited. Mr. Gulston came to the Newcastle firm from the Inman Line thirty-six years ago. During his service at Walker, Mr. Gulston has superintended machinery for a very varied class of vessels.—The Considère Construction Company, Limited, states that Captain H. E. Steinberg, who has been associated with the company practically since its inception, has been appointed manager of the company, in succession to Mr. T. B. Shore, who has resigned. Captain Steinberg has also been elected a director of the company.

Scientific Lighting and Industrial Efficiency.—In a lecture on "Scientific Lighting and Industrial Efficiency," at the British Scientific Products Exhibition, Central Hall, Westminster, on July 28, Mr. Leon Gaster pointed out the close relation existing between good industrial lighting and the health of workers, and gave many instances of accidents due to insufficient or badly-arranged conditions of illumination. Light, he said was a "tool," and it was absurd to instal expensive machinery and to pay highly-skilled workmen and then to neglect the relatively small expenditure on illumination necessary to the efficient performance of work. Instances were quoted showing that, as a result of improved lighting conditions, increases in output of 8 per cent. to 27 per cent. had been recorded; another factor of importance was the reduction in the amount of spoiled work. The cost of lighting formed only a small proportion, in some cases less than 1 per cent., of the wages bill. At the present time, when the need to increase our production was so great, and when the necessity of saving fuel was so evident, the applications of scientific methods to factory lighting was of special importance. During the last ten years much useful information had been acquired by the Illuminating Engineering Society in this country, one very important step being the development of simple instruments for measuring illumination. The Illuminating Engineering Society was in a good position to render assistance in making clear the essentials of good industrial lighting, by means of lectures and demonstrations.

DIE AND TAP-HOLDER.

We illustrate below a new pattern of die and tap-holder; it is of the self-releasing type, and is fitted with an automatic release action. The holder is being manufactured by the Phœnix Engineering Company, of 58, Church-street, Lee, S.E. 13, in five sizes, and is suitable for dies having a diameter of from 1 in. to 2½ in.

Fig. 1 shows the complete holder ready for work, and in Fig. 2 is shown a section through the holder in which the more important features are indicated.

The holder is held in the machine by the shank S. In Fig. 2 the die-holder is shown in the clearance position just after completing a thread of the required length. In this position the driving pins B have been withdrawn from the driving face of the slot D and depressed into the body of the driver through the action of the inclined planes E, the springs behind the pins B eliminate the solid jump and jar experienced in the more usual drive. On the reversal being effected, the

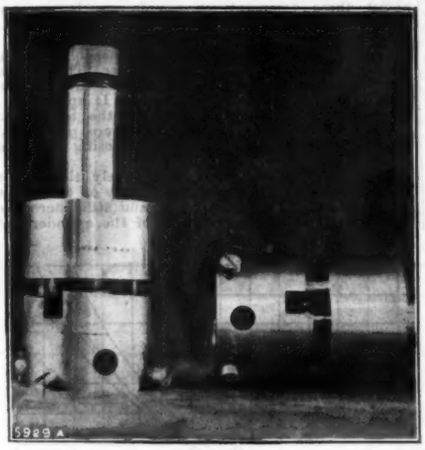
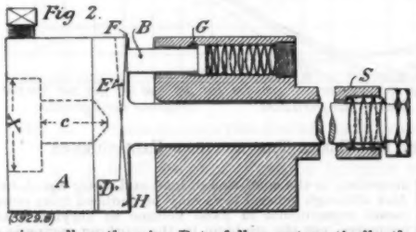


FIG. 1.



springs allow the pins B to follow automatically the inclined planes E to an amount equal to the clearance G, when they meet the projecting faces at H in the slot D, in which position they are ready for the reverse drive.

The patent die and tap-holder, it is claimed by the makers, prevents the kick and bumping action, thus reducing the wear and tear, and therefore the cost of maintenance.

The holder is case hardened throughout. The driving pins are made of tool steel and are hardened and ground. The sizes have been standardised and all the parts are interchangeable.

The length of thread which may be produced on a bolt or stud is governed by the depth of the clearance hole c in the body of the holder.

The following table gives the sizes at present being manufactured by the firm :—

Size No.	Dia. of Shank. (S)	Dia. of Die. (X)	Length of Thread Cut.
	in. in.	in.	in.
1	¼ or ⅜	1	1¼
2	½ or ¾	1¼	1½
3	1 or 1¼	1⅝	1¾
4	1¼	1⅞	1¾
5	1½	2¼	2¼

REVISION OF JAPANESE PATENT LAW.—According to a report published in the *Osaka Asahi*, the Japanese Government has established a Committee for the revision of the Patent Laws under the chairmanship of Mr. Inuzuka, Vice-Minister of the Department of Agriculture and Commerce. Three business men will have seats on this Committee, which is to meet shortly at the Department of Agriculture and Commerce in order to prepare a Bill for the next session of the Diet. The four existing Patent Laws, *i.e.*, Patent Law, Designs Law, Utility Models Law, and Trade Mark Law, will be revised separately.

THE LIMITS OF THERMAL EFFICIENCY IN DIESEL AND OTHER INTERNAL COMBUSTION ENGINES.*

By Sir DUGALD CLERK, K.B.E., D.Sc., F.R.S., M.Inst.C.E.

(*Concluded from page* 132.)

APPENDIX B.

ON THE DETERMINATION OF HEAT LOSS AND VARYING SPECIFIC HEAT OF FLAME AND THE PRODUCTS OF COMBUSTION IN THE ENGINE CYLINDER BY THE CLERK ZIGZAG DIAGRAM.

SOME years ago I devised a new method whereby the phenomena of heat loss and varying specific heat could be studied by indicator diagram and the actual working fluid behind the piston could be made to give information on these points during the progress of explosion, combustion and expansion in a working gas engine. The problem is a difficult one, and so far as my knowledge carries me, no previous attempt has been made even to determine a cooling curve for flame gases behind a moving piston. The method of experiment adopted by me was as follows :—

The engine selected for the first experiments had a cylinder of 14-in. diameter and 22-in. stroke; the

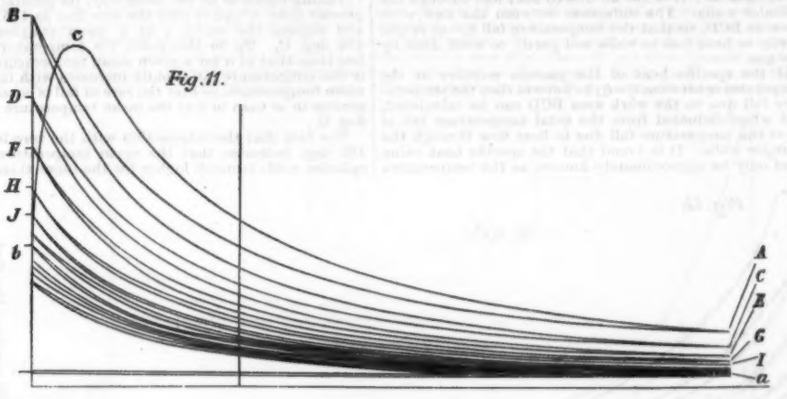


FIG. 11. CLERK DIAGRAM FOR DETERMINATION OF APPARENT SPECIFIC HEAT.

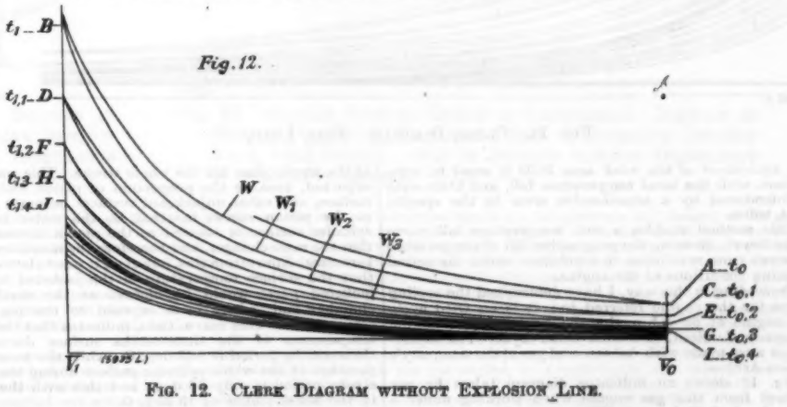


FIG. 12. CLERK DIAGRAM WITHOUT EXPLOSION LINE.

exhaust and inlet valve levers were supplied with longer pins than usual, so that the rollers mounted on these pins could be moved into or out of the range of the exhaust and inlet valve cams. When each roller was caused to slide to one end of its pin, the cam passed clear of it and the lever was not operated. When at the other end of the pin the roller engaged with the cam and the lever operated in the usual way. A spring and trigger gear was so arranged that the rollers could be put out of range of the cams at any required instant. By this contrivance the engine could be run in its normal way in accordance with the Otto cycle either at a light or heavy load, and any given explosion could be selected for the purpose of the experiment by operating the trigger at the proper moment. It was thus possible to run the engine at its normal speed under the usual propelling explosions, and to select at any given moment any particular charge, move the rollers out of the range of the cams immediately the charge entered, and so obtain an explosion and expansion stroke in the usual manner, with the usual charge. But both inlet and exhaust valves were held close and the charge retained in the cylinder. When the exhaust period was approached, the exhaust valve remained shut, and accordingly the hot exhaust gases were retained in the cylinder and compressed by the return stroke of the piston into the combustion space at the end of the cylinder. The energy of the fly-wheel was sufficient to keep up the rotations of the engine, with but little fall in speed during the short period of observation. The piston was thus caused to move to and fro, alternately compressing and expanding the hot gases which were contained in the cylinder so long as the gear prevented the operation of the inlet and exhaust valves.

An indicator card taken from such an initial explosion and expansion and the subsequent series of compressions and expansions is given at Fig. 11; *ab* is the ordinary compression line indicating the compression of the charge before explosion, *bc* is the usual explosion line, and *cA* the usual expansion line after explosion. At A, however, instead of the pressure falling to the atmosphere by the opening of the exhaust valve, as the exhaust valve remains closed no escape of the hot products of combustion is possible, and accordingly the return of the piston produces the compression line AB; the next outward movement of the piston produces the expansion line BC; followed by the compression line CD; expansion line DE; compression line EF; expansion line FG; compression line GH; expansion line HI, and so on. In this diagram the successive compression and expansion lines have continued to be traced until the fall of pressure due to cooling brings the contents of the cylinder at the outer end of the stroke below atmospheric pressure, when the outer atmosphere opens the valves against the pressure of their springs, and so the experiment terminates. It will be observed that cooling is proceeding during the tracing of all these lines; had no cooling occurred on any particular expansion and compression stroke, the compression line would lie on the top of the expansion line. Consider, for example, the moment represented by the point B when the piston is at the extreme inner end of its stroke; then the combustion space is filled with hot gases at a temperature and pressure corresponding to the point B; after a complete expansion and compression, one out- and one in-stroke of the engine, a complete revolution of the crank, the piston is again at its innermost position, and the whole of the gases are again contained in the combustion chamber at a pressure and temperature marked by the point D. This point D is lower than B, and as the weight of the gaseous contents has not changed, it follows that the temperature at D is lower than at B. The points B, D, F, H and J thus indicate the temperatures of the gases at the same volume at intervals of one revolution of the engine.

If the engine be running at 120 r.p.m., then the temperatures represented by the points D, F, H and J give the successive temperature falls suffered by the contents during successive revolutions, each lasting 0·4 seconds. In the same way the successive temperatures of the gaseous contents at the out ends of the stroke are given by the pressures at A, C, E, G and I. Call the successive temperatures at the out end t_0, t_{01}, t_{02}, t_{03}, and t_{04}, corresponding to the points A, C, E, G, and I, and the temperatures at the inner end of the stroke t_1, t_{11}, t_{12}, t_{13}, t_{14}, corresponding to the points B, D, F, H

* Paper read before the North-East Coast Institution of Engineers and Shipbuilders, 1919.

and J. These temperature changes are partly due to heat loss from the gases to the cylinder walls and partly due to work done on the piston by the gases or by the piston on the gases. The points at both ends of the stroke when properly dealt with give curves of temperature fall due to heat loss to walls.

Fig. 12 shows a compression and expansion diagram without the explosion line.

Consider first the series of points at the inner end of the stroke; obviously, if no cooling took place in the cylinder there would be no fall of temperature, such as is shown between B and D. The fall between B and D is not entirely due to cooling, as will be seen when we consider what happens to the gases between the points B and D. When the engine piston expands the gases from B to C and compresses from C to D, a portion of the total heat has passed through the cylinder walls, but some work has also been done by the gases upon the piston. When the expansion BC takes places, the gases perform work on the piston equal to the area B C V V_1; when the compression CD takes place the piston performs work on the gases equal to the area C D V_1 V_0, so that more work has been performed by the gases on the piston than by the piston on the gases. Some work has therefore been done by the gases in the processes intervening between the points B and D; that is, part of the temperature difference t_1—t_{11} is due to work done; it is not all due to heat lost through the cylinder walls. The difference between the two work areas is BCD, so that the temperature fall t_1—t_{11} is due partly to heat loss to walls and partly to work done by the gas.

If the specific heat of the gaseous mixture at the temperatures between t_1—t_{11} be known, then the temperature fall due to the work area BCD can be calculated, and when deducted from the total temperature fall it gives the temperature fall due to heat flow through the cylinder walls. It is found that the specific heat value need only be approximately known, as the temperature fall equivalent of the work area BCD is small in comparison with the total temperature fall, and little error is introduced by a considerable error in the specific heat value.

This method enables a true temperature fall curve to be drawn, showing the progressive fall of temperature incurred from revolution to revolution under the actual working conditions of the engine.

Proceeding in this way, I have determined the cooling curve for the engine referred to; it is an Otto cycle gas engine of 60 b.h.p. by the National Gas Engine Company, Limited, of Ashton-under-Lyne. The experiments were made with Ashton coal gas at the company's works, Ashton.

Fig. 13 shows an indicator diagram taken by my method from this gas engine when working under a brake load of 50 h.p. at 160 r.p.m., water-jacket at a temperature of about 71 deg. C. A Richards-Casartelli indicator was used.

The temperature of the charge before compression was calculated at 95 deg. C. The diagram was taken under full loads.

Proceeding in the manner described, I have prepared cooling curves from the engine under two conditions—first, with no load and the cylinder kept cool, engine running at 120 r.p.m.; and, second, with full load and the jacket water hot (71 deg. C.), engine running at 160 r.p.m. The cooling curves show the temperature fall due to heat loss, with mean temperatures of the gases varying from 100 deg. C. to 1,500 deg. C., and exposure calculated to one second time. The curves show the rates of temperature fall found under these conditions for complete strokes and partial strokes of three-tenths of the whole at the compression end.

Fig. 14, on the present page, gives the temperature falls incurred per second for different mean temperatures calculated in time.

Consider first the curves a a^1. These correspond to the conditions in the engine cylinder when the engine is running at 120 r.p.m. without any load, so that very few ignitions keep it in motion, and while the water jacket is kept cold by running water at 13 deg. C. freely through it. Under these conditions the end of the piston and the interior surface of the valves will be but little heated by the explosions, and the interior surfaces of the cylinder and combustion space wall will tend to fall between the explosions to the water jacket temperature of 13 deg. C.

The curve a is that for the complete strokes, while a^1 is for the partial first three-tenths of the stroke. Taking a first, it appears that the rate of temperature fall per second for a mean temperature of 1,300 deg. is 1,460 deg. C.; that is, that a complete stroke of the engine during which the mean temperature in the cylinder was 1,300 deg. C. would lose heat to the walls at a rate sufficient to produce a temperature fall of 1,460 deg. C. per second. The stroke in this case does not last a second, but only a quarter of a second, so that the real temperature fall under these conditions would be $\frac{1460}{4} =$ 365 deg. C. It is better, however, to express the temperature fall in degrees per second.

The curve a, when prolonged to the zero of temperature fall, cuts it at the temperature of 65 deg. C., which means that when the gases within the cylinder fall to the mean temperature of 65 deg. C., no further heat loss occurs to the enclosing walls—that is, the mean temperature of the enclosing walls for the complete stroke of the engine must be 65 deg. C. The water outside does not succeed in keeping down the mean temperature of the interior surface, including valve surfaces and piston end, to its own temperature of 13 deg. C. This curve thus gives an interesting indication of the mean temperature of the walls.

Taking curve a^1 in the same way, its general slope is greater than a, and it cuts the zero line at 165 deg. C., and crosses the curve a at a mean temperature of 610 deg. C. Up to this point the temperature fall is less than that of a for a given mean temperature, above it the temperature fall rapidly increases with increasing mean temperature, so that the rate of fall is considerably greater in a^1 than in a at the mean temperature of 1,300 deg. C.

The fact that the intersection with the zero line is at 165 deg. indicates that the mean temperature of the cylinder walls is much higher for the inner three-tenths of the stroke than for the whole stroke. This was to be expected, because the proportion of piston end, valve surface, and other unjacketed surfaces becomes greater as the piston moves in—that is, the water jacketed cylinder surface is covered as the piston moves in, so that the ratio changes, and therefore the mean temperature rises. Apart from this, however, it was to be expected that the surface temperature of the jacketed and unjacketed parts would be highest at the combustion chamber end, where it is exposed to the maximum temperature. This curve, then, indicates that the mean temperature of the three-tenths surface during the three-tenths period is 165 deg. C., while the mean temperature of the whole cylinder surface during the whole stroke period is only 65 deg., and this with the water in the water-jacket at 13 deg. C.

Comparing now the two curves a, a^1, at the mean temperatures 1,300 deg. C., 1,200 deg. C., 1,100 deg. C., 1,000 deg. C., 900 deg. C., it is found that the rate of loss of temperature is less in curve a than in a^1 by the following percentages, calculated on the a values for the successive temperatures; nearly 26 per cent., 20·5 per cent., 16 per cent., 13 per cent., and 10 per cent.

This clearly shows that, notwithstanding the diminutions of surface exposed in a given time at three-tenths stroke, as compared with whole stroke, the absolute temperature fall rate is increased. This is probably due to the fact that the mean surface exposed diminishes more slowly than the mean density increases, so that the economical effect of increased density is not realised. The existence of some turbulent motion may also mark the other effects. This clearly shows that it is necessary to determine cooling in the cylinder with the moving piston, as the conditions are too little known to be predicted from explosions in closed vessels of fixed capacity. This becomes even more evident when the curves b, b^1 are studied. The curves b, b^1 are taken while the engine is running at a load of 50 b.h.p. Here the explosions are almost consecutive, and the water-jacket temperature is 80 deg. C., so that the interior surfaces, both jacketed and unjacketed, are much hotter than in curve a, a^1, as before, curve b is for whole stroke, and b^1 for first three-tenths of stroke. Curve b cuts the zero line at 190 deg., indicating the mean temperature of the enclosing walls during the whole stroke. The condition of the internal surfaces is different—190 deg., as compared with 65 deg., a very large increase in temperature. Curve b^1 cuts the zero line at 400 deg., also a much higher temperature. The continued explosion and the hot-water jacket have produced a very considerable change upon the surface temperature of the enclosing walls. Here also the curve b for the whole stroke is less steep than b^1 for the three-tenths stroke, but, owing to the high wall mean temperature at three-tenths, the curves do not intersect till the temperature of 1,100 deg. C. is reached. Below 1,100 deg. C. the temperature fall is less in b^1; above that temperature it is greater.

Comparing b, b^1 as a, a^1 have already been treated at the same mean temperatures. For 1,300 deg. and 1,200 deg. C. the temperature fall is greater in b^1 than in b, but only 4 per cent. and 2 per cent., respectively, calculated on b^1; at 1,100 deg. C. the temperature fall is practically equal; at 1,000 deg. b^1 is less by about 3 per cent. on b^1 and 900 deg. C. is nearly 7 per cent. less, also calculated on the value of b^1.

It is thus seen that for the practically interesting range of mean temperatures, 1,300 deg. C. to 900 deg. C. the temperature fall given by the two curves varies but little, and this is due to the higher average temperature of the interior surface in the first three-tenths of the stroke. The point of intersection of the curves b and b^1 is raised to such a high value that the actual heat loss about these temperatures remain nearly constant, although the two curves are undoubtedly different in their slope.

Compare now the curves a^1, b^1, and it will be seen that they are fairly parallel one to the other. Their general slope is very similar, so that, except at the lower end they could be almost superimposed. It appears as if the difference in absolute value of the temperature fall for given mean temperatures were due mainly to the difference between the enclosing wall temperatures.

Those experiments prove conclusively that cooling behind a moving piston depends largely on the varying temperature of the water-jacket, and still more upon the varying mean temperatures of the cylinder walls according to the condition of load and water circulation. And although general laws may be deduced from closed vessel experiments of fixed volume at varying initial pressures, yet the problem in the working engine is so complex that it is desirable to make many direct determinations on actual engines as to explosions and cooling in cylinders of varying dimensions before endeavouring to deduce any general formulæ.

From the curves given in Fig. 9, and specific heat values of the gaseous contents of the cylinder, heat losses can be calculated on the explosion expansion line independently of any knowledge as to the completeness of combustion at any point, and for this purpose I have determined the specific heat of the gases in the following manner:—If a gas be compressed without gain or loss of heat from volume V_0 to V_1, and the temperature rises from T_0 to T_1, so that the work done upon the gas is W, then the mean specific heat Cv of the gas per unit volume at 0 deg. and 760 mm. at constant volume between the temperature is

$$C_v = \frac{W}{\psi_0 (T_1 - T_0)}$$

where ψ_0 is a constant depending on the quantity of the gas in the cylinder.

This is also true of expansion as well as compression. The dynamical value of the rise or fall of 1 deg. C. for 1 cub. ft. of the gas will be given by the same formula:—

$$D_v = \frac{W-1}{V(T_1 - T_0)}$$

where W is the work done by or on the gas in foot-pounds, V is the volume in cubic feet, and D_v is the dynamical value in foot-pounds.

It is evident that the method of operation just described affords the means of determining the heat loss on expansion or compression lines, and so permits the temperature fall or rise, due to work done, to be determined at any temperatures. In this way I have experimented on the products of combustion contained within the gas-engine cylinder, and deduced the values of D_v for that working fluid at different temperatures.

The experiments were numerous, and many difficulties were encountered; for the full discussion I refer to the Paper describing the experiments read by me before the Royal Society in 1906. (Proceedings Royal Society, A., vol. lxxvii., 1906, page 499.)

Fig. 13.

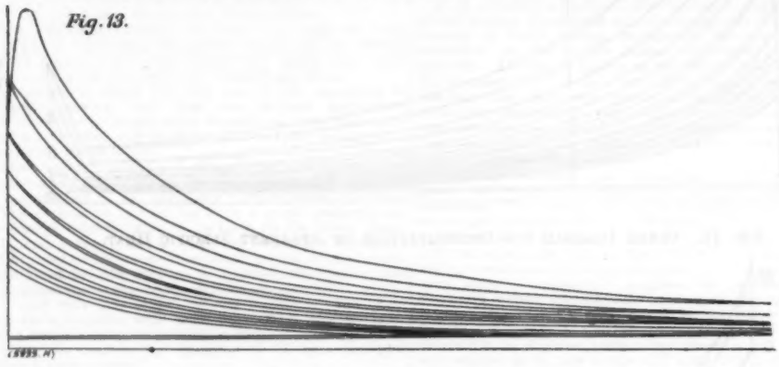


Fig. 13. Clerk Diagram. Full Load.

Fig. 14.

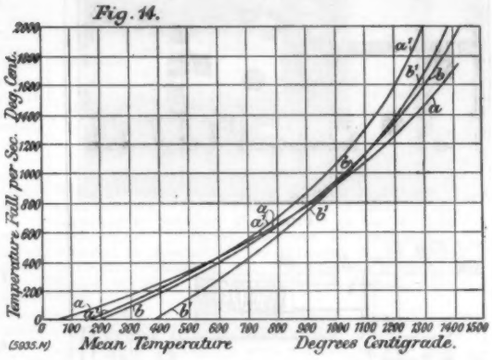


Fig. 14. Clerk Temperature Fall Curves.

APPENDIX C.

ON THE EFFECT OF TURBULENCE IN INCREASING THE RATE OF IGNITION IN GAS AND PETROL-ENGINE CYLINDERS.

Extract from the Fifth Report of the British Association Gaseous Explosions Committee, Dundee Meeting, 1912.)

Turbulence.—During the suction stroke of a gas engine, or during the period of injection in an engine charged from a separate compressor, the mixture of gas and air which is subsequently to be exploded enters the engine through the valves or ports at a high velocity, so that the gas within the cylinder is in a state of eddying or turbulent motion. This motion gradually dies away after the valves are closed, but will persist for some time during the compression stroke, so that at the moment of explosion there may still be a good deal of turbulence. In consequence of this motion of the gas the convection of heat will go on more rapidly, and what may be called the "effective conductivity" of the gas will be increased.

Perhaps the most obvious direction in which to look for the effects of turbulence in gas engines is the relation between speed and fuel economy, and this aspect of the matter has been discussed by Callendar, Lanchester and others. On the one hand, it may be expected that the longer the time taken over the operations of compression and expansion, the more heat, other things being the same, will pass into the walls during that period. As against this must be set the consideration that, with a given valve opening, slow speed means less turbulence, first, because the velocity of entry of the gas is less, and, second, because the time available for the resulting turbulence to die out under the influence of viscosity is longer. Reduction of speed, therefore, means less effective conductivity, and it is even conceivable that on this account the heat-flow per cycle may be less and the fuel economy greater at the lower speed. The effect of heat-flow upon economy is not very marked, and it is therefore not surprising that no decisive verdict has yet been pronounced on the relation between economy and speed. There is no doubt that, given satisfactory ignition, economy is somewhat improved by increasing the speed, but the relation between these two things has not been so precisely determined as to permit a conclusion to be drawn about the part played by turbulence, nor in view of the complication of the question does it seem likely that much information can be derived from this source. A more promising line of inquiry would be a direct measurement of jacket-losses at different speeds. The committee are not aware that any very accurate measurements of jacket-loss at different speeds, other conditions being kept rigorously the same, have ever been undertaken. From some rather rough measurements of this character made by various members of the committee, it appears that the heat-loss per cycle does undoubtedly diminish with increase of speed, but not in proportion thereto.

The complete elucidation of the part played by turbulence in the working of a gas engine seems, however to require more direct method of investigation than the ordinary tests. During the past year, Dugald Clerk has applied his method of indicating the engine with tripped valves, so as to obtain a "zigzag" diagram, to the investigation of this point. During the first expansion line in such a diagram there is present the normal amount of turbulence which obtains in the ordinary working of the engine; during the second and later expansions of the "zigzag" the turbulence has practically died out. We have here obviously a method of considerable delicacy for detecting and measuring the effect of turbulence in causing heat-loss on the expansion line. Clerk has found that in the compression and expansion of air or carbon dioxide without firing, the engine being simply motored round, the rate of heat-loss at a given temperature is greater in the first compression after drawing in the charge than in the subsequent compressions.

For the purpose of studying by this method the effect of turbulence on heat loss in the ordinary working stroke of a gas engine, Clerk tried the experiment of drawing in a combustible charge into the engine in the ordinary way and then tripping the valves and compressing and expanding this charge for one or two revolutions before firing. By this means the turbulence which, in the ordinary method of working, persists till the moment of firing was given time to die away. It was expected that a comparison of an expansion line obtained in this manner with that following a normal ignition would show the effect of turbulence on heat-loss. While the experiment did not give any very clear indication on this point, it was the means of bringing to light a matter of perhaps greater importance. Clerk found that the result of damping down the turbulence was to retard the rate of inflammation of the gas to a very remarkable extent, so that the character of the diagram was completely altered. Two of Clerk's diagrams are reproduced (see Figs. 15 and 16), from an inspection of which the importance of this point in the working of gas engines will be appreciated. If ignition be delayed until the combustible mixture taken into the engine has been compressed and expanded twice and then again compressed, the period of inflammation is about two and a half times that of a normal ignition in which the gases have some turbulent motion. The diagrams shown, Figs. 15 and 16, were taken by an optical indicator from an engine of 9 in. diameter cylinder and 17 in. stroke when running under full load at 180 r.p.m. The engine was fitted with two electric igniters; one operating at the charge inlet-valve at the back of the combustion chamber, and the other operating at the side of the cylinder close to the piston. In Fig. 15 the back electrical ignition was used, and in Fig. 16 the side igniter was in operation. It has been noticed more than once that the period of inflammation in the gas engine is considerably less than that obtaining in an explosion of a similar mixture in a closed vessel of the size of the combustion chamber, and it must have occurred to many that, were it not for this fact, it would hardly be possible to work internal combustion engines at reasonably high speeds because the ignition would be too slow. It now appears that this is wholly, or almost wholly, due to the fact that the gas in the engine is in turbulent motion.

Simultaneously with the experiments by Dugald Clerk, described in the last paragraph, Professor Hopkinson (with the assistance of his pupils, Messrs. Miley and Peache) carried out some measurements of the effect of turbulence on heat-loss and inflammation phenomena in a closed-vessel explosion. A cylindrical vessel, 1 ft. in diameter by 1 ft. long, was used and was lined with copper strip, the rate of heat-loss being measured by a record of the rise of electrical resistance of this strip. A small fan was mounted in the centre of the vessel and comparisons were made of the result of exploding the same mixture, first with the fan at rest, and second when the fan was driven at a speed of several thousand revolutions per minute. These experiments also showed the great increase in speed of inflammation consequent on the motion of the gas. Taking a mixture of 10 per cent. of coal-gas and 90 per cent. of air, the time for ignition to maximum pressure with the gas at rest is about 0·13 second; with the fan running at 2,000 r.p.m. this time was reduced to 0·03 second, and at a speed of 4,500 r.p.m. to 0·02 second. The effect on heat-flow was also very marked. At maximum pressure, with a 10 per cent. mixture, the rate of flow of heat was, approximately, doubled when the fan was running at a speed of 4,500 r.p.m., the mean temperature of the gas in the two cases being the same (about 1,600 deg. C.). It is interesting, however, to note that at the higher temperatures reached with a 15 per cent. mixture—say, at 2,000 deg. C.—the heat-flow from the gas was not materially altered by the turbulent motion produced by the fan. This is doubtless due to the fact that at such temperatures radiation is an important agent in the transfer of heat, and this would probably be unaffected by the motion of the gas.

For the application of the results obtained with the closed vessel and the fan to the gas engine, it is necessary to get some measure of the amount of turbulence remaining in the latter at the end of the compression stroke. Mr. H. J. Swain, under the direction of Professor Hopkinson, has made some measurements during the past year bearing upon this point. It is hoped that full details of these experiments, and of those cited above, will be published in the course of the next few months, and the results only need be given here. The method used was to determine the rate of loss of heat from a platinum wire mounted in the combustion chamber of a gas engine; the wire being heated by an electric current. Within moderate limits of temperature the heat-loss from such a wire is proportinal to the temperature difference between it and the surrounding gas. The ratio between heat-loss and temperature difference is a measure of the effective conductivity of the gas, and depends upon its temperature, density, and state of motion. If the first two factors are the same, then the effective conductivity depends only upon the state of motion, and may be taken as a measure of its amount. The wire was mounted in the combustion space of an engine of 7-in. bore and 15-in. stroke, which was motored round so as to compress and expand charges of air, the gas supply being cut off, and comparative measurements of effective conductivity at the top of compression were made first with the engine valves working in the ordinary way, and, second, with the valves closed, so that the same charge of air was continually compressed and expanded, and there was therefore no turbulence resulting from suction. It was found that at 240 r.p.m. the conductivity was more than 60 per cent. greater in the first case than in the second, while at 60 r.p.m. the difference was only about 20 per cent. In these comparative experiments the temperature and density of the gas were the same, and the difference could only be due to the motion. From measurements of the heat-loss from a similar wire in the closed vessel, Hopkinson infers that the motion of the gas with a fan speed of 2,500 r.p.m. is probably considerably greater than that obtaining in the gas engine. At this speed the heat-flow at a temperature of 1,600 deg. C. or over is increased by an amount of the order of 25 per cent., and, while it is certain that turbulence is responsible for some increase of heat-flow in the gas engine, it is improbable that this is such as materially to affect the thermal efficiency, though it is of importance in the problem of cooling. The great influence of this factor on this manner of inflammation which has been disclosed by these experiments of Clerk, and of Hopkinson also, makes the subject worthy of more detailed investigation.

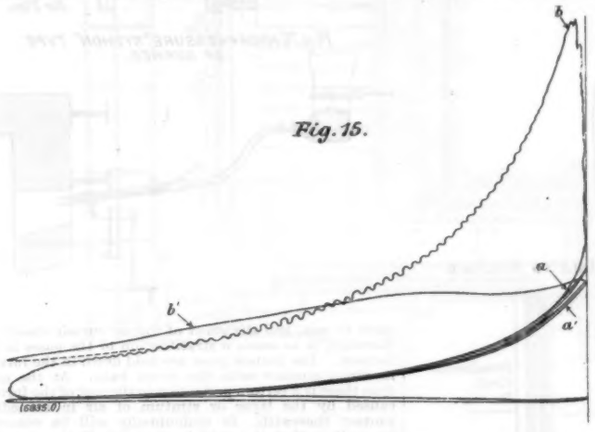


Fig. 15.

FIG. 15. DIAGRAM SHOWING EFFECT OF TURBULENCE. IGNITION AT BACK OF COMBUSTION CHAMBER. TIME OF ORDINARY IGNITION $a - b$, 0.037 SECOND. TIME OF IGNITION WITHOUT TURBULENCE $a^1 - b^1$, 0.092 SECOND.

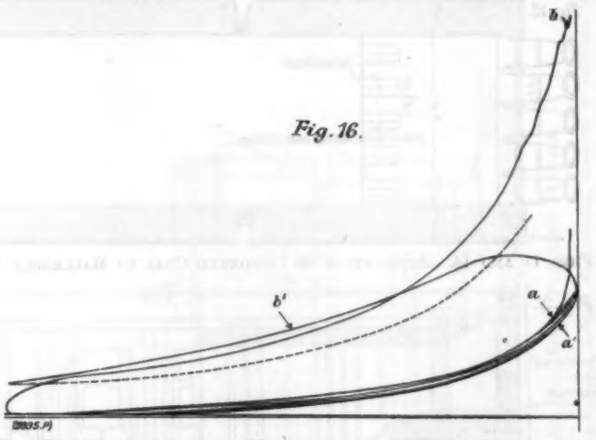


Fig. 16.

FIG. 16. DIAGRAM SHOWING EFFECT OF TURBULENCE. IGNITION AT SIDE OF COMBUSTION CHAMBER. TIME OF ORDINARY IGNITION $a - b$, 0.033 SECOND. TIME OF IGNITION WITHOUT TURBULENCE $a^1 - b^1$, 0.078 SECOND.

SWEDEN'S COAL REQUIREMENTS.—Mr. G. K. Hamfeldt, president of the Oxelösund Iron Works Company, was in Pittsburg recently, says *The Iron Age*, to investigate the matter of buying coal for coking purposes, for a plant of 60 Koppers by-product coke ovens, which his company operates in Sweden. Mr. Hamfeldt, however, found that prices of coal in Pittsburg were so high, and freights to Sweden so excessive, that it was not feasible to buy coal in the Pittsburg district, and it is understood that he did not make any purchase. Mr. Hamfeldt was for some years superintendent of the Carrie blast-furnaces of the Carnegie Steel Company, Rankin, Pa.

COMBINATION IN BELGIAN METALLURGICAL INDUSTRIES.—The consolidation of interests in the Belgian glass industry has already been announced, and the movement appears to be taking root in other industries, says *The Board of Trade Journal*. According to the Press a metallurgical trust, representing 300,000,000 fr. capital, is in process of formation. It is expected, in spite of the opposition of conflicting interests, that this will embrace the whole industry. After rebuilding and re-equipping existing works, the trust proposes to build three or four large factories, each specialising in the production of selected classes of goods.

THE USE OF PULVERISED COAL.

*Use of Pulverised Coal, with Special Reference to its Application in Metallurgy.**

By L. C. HARVEY (London).

(*Concluded from page* 128.)

THE LOCOMOTIVE PULVERISED FUEL COMPANY'S AND THE POWDERED COAL ENGINEERING COMPANY'S SYSTEMS.

The special feeder mixers and carburettors supplied by these companies, together with the locomotive equipment supplied by the former company, are described n the "Report."

APPLICATIONS.

Malleable Iron Furnaces.—Figs. 17 and 18 show the method of applying powdered coal to a malleable iron melting furnace in which temperatures between 3,000 deg. F. (1,650 deg. C.) and 3,220 deg. F. (1,770 deg. C.) can be obtained with air at 60 deg. F. (16 deg. C.), and higher temperatures will result with pre-heated air.

Melting conditions are under perfect control, and at this degree of heat there is of necessity little free oxygen present, so that the burning out of valuable elements such as carbon and silicon is avoided, and melting takes place with a very low loss.

By the use of powdered coal the flame can be directed on to the bath of metal; thus it becomes possible to dispense with the "top air" jets usually provided on hand-fired furnaces in order to force the hot gases away from the roof brickwork and on to the metal bath.

Mr. Joseph Harrington† has given a concise explanation of the radiant heat effect of minute incandescent carbon particles, the benefit of which is fully realised with pulverised fuel. For the information of those who may not be able to obtain access to this information, it will not be out of place to quote from Mr. Harrington's second article. When comparing older methods with that of coal-dust firing, he remarks that in ordinary practice air, usually known as top air, is introduced into the furnace from above. This supplies the necessary oxygen for the complete burning of the hydrocarbon gases evolved in the fire-box; and also serves to force the hot burning gases down on to the metal bath.

It has been customary to apply this secondary air by means of from four to six nozzles, spaced across the top of the furnace and slanting downward towards the metal bath. It is almost obvious, however, that 2-in. jets of air spaced 15 in. or 20 in. apart will not have a character other than that of jets. The space between the jets is filled with furnace gas inadequately supplied with air, and in all probability it is this gas which finds its way along the furnace roof and eventually burns, if at all, in the rear of the furnace or in the flue leading to the stack.

Powdered Coal as a Gas.—Considering now the radical difference between this method and the conditions which obtain with pulverised coal in suspension in a stream or jet of carrying air, one must conceive of the powdered coal having the character of gas in order fully to appreciate the controllability of the flame both as to direction and velocity and extent. The nozzles in this case are placed in such a manner that the fuel jet itself is directed downward toward the hearth. The velocity of the jet being controllable, the flame can be made practically any length desired. By using a high-velocity jet it would be possible to cause the flame itself directly to strike the liquid iron and spread out in a continuous sheet over the surface of the metal, or to mingle intimately with the pile of iron on the hearth. On the other hand, it is equally possible to decrease the velocity of the jet to a point where it reaches the right part of the furnace close to the metal, and thereupon loses the velocity acquired at the nozzles, and becomes a floating mass of gas moving with relative slowness through the furnace. To hold the sheet of slowly moving but very intensely heated gas near the surface of the metal a relatively thin, continuous sheet of air can be introduced in the same place in which the top air nozzles ordinarily are located. It is obvious that this secondary air, if introduced in a uniform sheet the entire width of the furnace, at least, at the moment of its introduction, will spread out into a very thin layer, having a maximum of exposed surface and a minimum of gaps through which unburned gases can pass.

In the malleable melting furnace, after the pile has begun to subside, there is little or no tendency for the gases to mix, and the effect of the air curtain described, therefore, is to cause a stratification of the gases in the furnace. The hottest gases are held down in the furnace in direct contact with the metal bath. At the same time there is a certain protection to the roof of the furnace caused by the layer or stratum of air in immediate contact therewith. It undoubtedly will be conceded by melters that it would be desirable if the roof of a melting furnace could be lowered after the metal pile subsides, and during the latter part of the heat until the clearance between the roof and the hearth should be cut in two. But it is necessary to have the roof a certain height in order to make it possible to charge the furnace, and this height, of course, has to be maintained at all times. However, the effect of lowering the furnace roof can largely be accomplished as previously indicated, and with a highly preheated air under control the incandescent, pulverised coal flame can be made to skim along the surface of the bath in direct physical contact therewith, and in the very best position to give up the maximum amount of heat thereto.

It is perhaps obvious from the foregoing that the beneficial result obtainable from the better contact of gas and metal and the utilisation of the radiant heat, is a quicker melt with less burning out of the desirable elements of silicon, manganese and carbon.

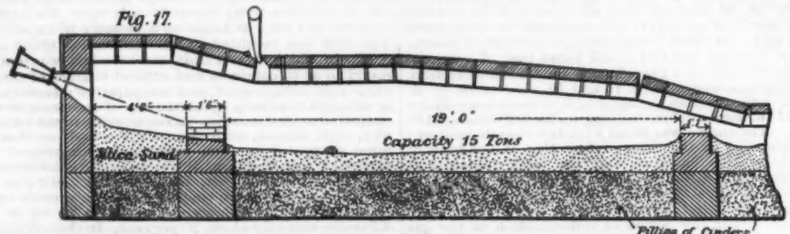
With pulverised coal it is possible to get an incandescent front within a few minutes of the time of starting, even though the furnace be perfectly cold at first. The high temperature is maintained consistently until tapping is begun. It is inevitable that the iron should melt quicker under these conditions, and just as inevitable that the losses of valuable ingredients should be reduced. Slag troubles do not occur because the ash liquefies and runs down on to the metal bath, from which it is skimmed periodically with the rest of the slag. The conservation of the carbon, &c., has a directly favourable influence on the amount of high-grade iron to be charged, and a definite saving, variously estimated from 2 per cent. to 5 per cent., is the result.

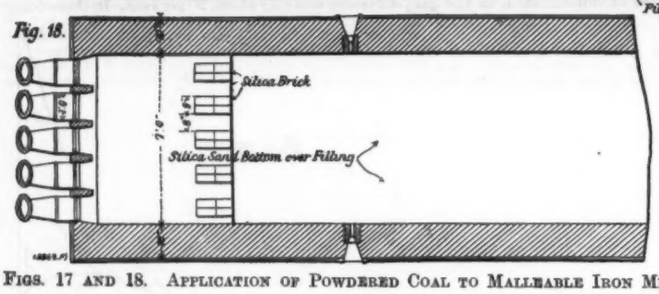
Open-Hearth Melting Furnaces. Burners.—For the general run of metallurgical furnaces burners of simple design are used. These consist mainly of an air-blast pipe into which the coal dust is fed from the screw feeder. The dust falls into the air stream, and in this way is carried into the combustion chamber.

Certain special burners or mixers have been designed, whereby a premixing of the coal dust and air is effected in one or more stages before the final mixture emerges from the burner nozzle.

With the simple type of burner having the one air-supply pipe, fine adjustment of the mixture can be effected by means of a natural-draught sliding cone section.

For melting steel in the open-hearth furnace it is desirable to project the flame on to the centre of the bath, so that at each reversal the one or other end receives the greater intensity of heat. Burners for this purpose are, therefore, generally operated with high and low pressure air, the burners being made with swivel joints,





FIGS. 17 AND 18. APPLICATION OF POWDERED COAL TO MALLEABLE IRON MELTING FURNACE.

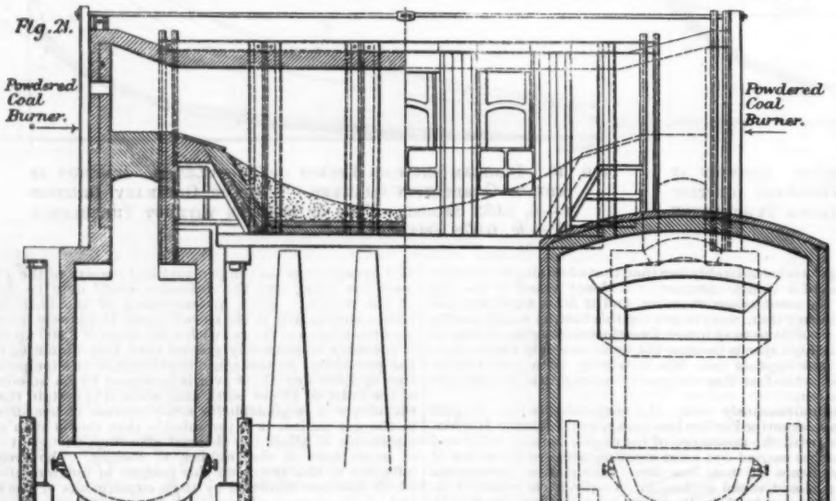


FIG. 21. OPEN-HEARTH FURNACE, SHOWING ASH BOGIES BENEATH DOWNTAKES. (PERKINS-FITCH PATENTS.)

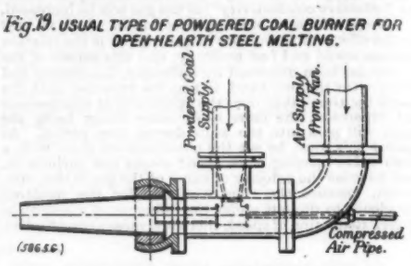
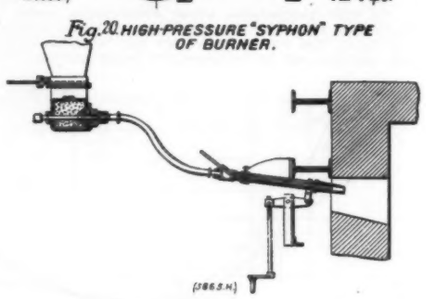


Fig. 19. USUAL TYPE OF POWDERED COAL BURNER FOR OPEN-HEARTH STEEL MELTING.
Powdered Coal Supply.
Air Supply from Fan.
Compressed Air Pipe.



* Paper read before the Iron and Steel Institute on Thursday, May 8, 1919.

† *The Foundry*, October, 1916 and December, 1918.

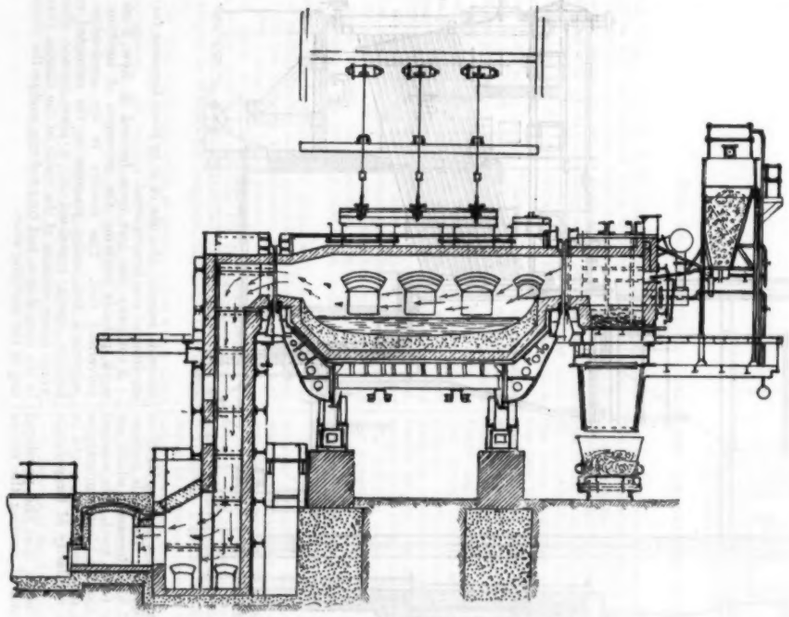


FIG. 22. POWDERED-COAL-FIRED TILTING FURNACE.

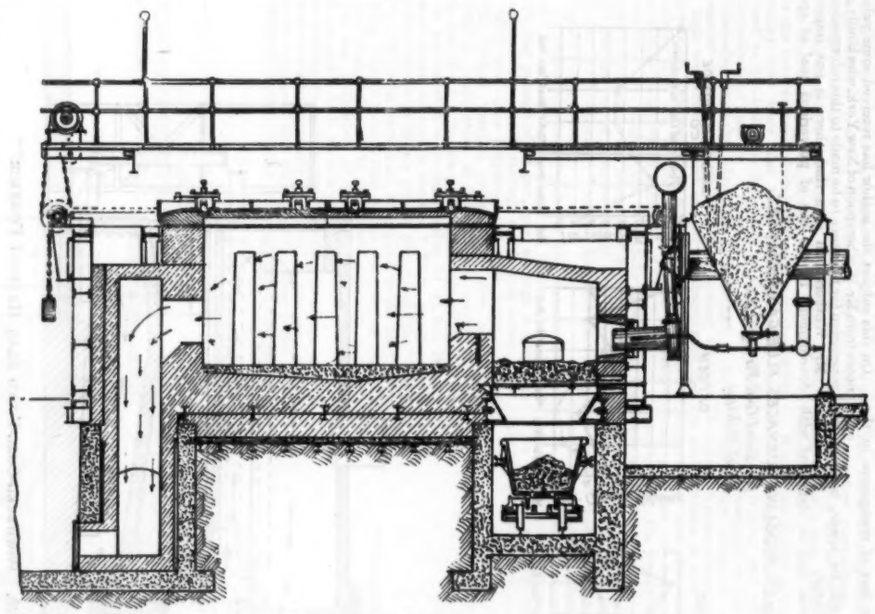


FIG. 23. POWDERED-COAL-FIRED SOAKING PIT.

so that the flame can be projected in the direction required.

The usual type of burner is shown in Fig. 19, and screw-adjusting gear is usually fitted, so that the nozzle section can be moved in order to control the direction of the flame. This burner is for working with low-pressure air at the main supply, and with a small proportion of compressed air to effect thorough mixing of the air and coal dust through expansion of the high-pressure supply.

The next illustration, Fig. 20, shows a burner to work with compressed air only; the coal dust in this case is syphoned out of the fuel chamber.

It is general practice to arrange the burner nozzle in front of a natural-draught inlet port. Overheating of the burners does not take place, because at each reversal the burner is usually withdrawn and an iron slide lowered over the inlet port.

In certain instances this operation is automatically performed, the starting and stopping of the air and coal dust supplies being operated by electrical control gear working in synchronism with the reversal of the chequer valves.

The use of high-pressure air for open-hearth steel furnaces enables the full flame temperature to be developed in close proximity to the metal and avoids the overheating of the refractory walls.

The application of powdered coal to open-hearth furnaces has not been so generally carried out as for other purposes in steelworks, but of recent years much progress has been made.

It is quite possible to melt steel with powdered coal and cold air, but the time required under these conditions for melting is too long.

Pre-heated air is always used, and this is generally effected in the existing regenerative air chambers, in which much trouble was at first experienced with ash deposit. Furnaces heated by this means can be so designed as to overcome the ash trouble, and this can very often be accomplished on existing furnaces.

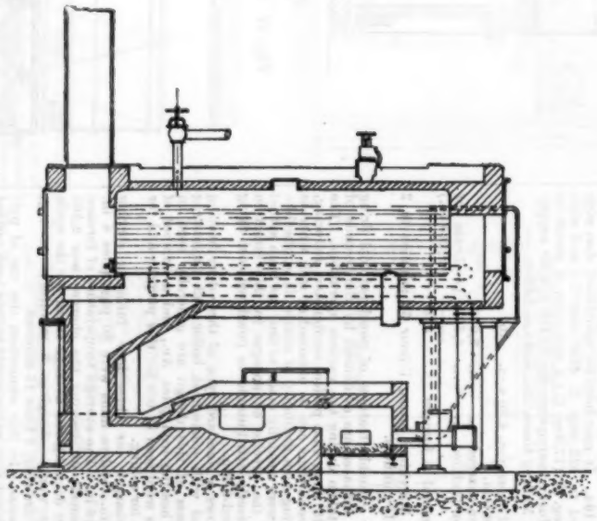


FIG. 24. POWDERED-COAL-FIRED PUDDLING FURNACE.

Fig. 21, on page 160, shows a 40-ton open-hearth furnace with ash bogies placed below the down-take flues, in which a very large quantity of the ash particles carried through the melting chamber is collected before the gases enter the checker-work.

With a suitable fuel, finely pulverised and applied in approved manner in conjunction with heated secondary air, excellent results have been obtained in America, and the use of powdered coal for this purpose has now reached a practical and successful stage.

This matter was recently referred to in *Blast-Furnace and Steel Plant* as follows:—

"While for heating furnace work many kinds of coal are available for powdering, the list of available coals for open-hearth work is small. Small sulphur content and small ash content together with high volatile content are extremely desirable. Many failures of powdered coal for open-hearth work are due to the purchasing of a cheap coal. Regenerators must be so designed that fused ash can be deposited in a removable slag pocket before the flue gases reach the checker-work. The latter must be fairly open. Good success has been attained by making the gas passages tubular without dead spaces or projecting corners which may favour deposit. From snowstorms it is known that snow drifts into places where the air is stagnant, and accumulates there. Ash in flue gases does the same. Easy bends of tubular construction and without sudden changes in cross-section are therefore recommended.

"To avoid deposits of ash, the coal must be very finely ground. The finer the coal, the slower the air current in which it will remain afloat. Installations of grinders much larger than absolutely necessary are recommended, because overloading of pulverising apparatus causes coarse grinding. If the grinding is fine enough, if the regenerators are properly designed, and if a good coal is burned, practically all of the ash* is carried out through the stack in the shape of a scarcely visible whitish haze. If these precautions are not used, and particularly if a cheaper grade of coal is used, frequent repairs to the furnace regenerator are necessary; in some places the regenerators have to be cleaned out

* Presumably that portion of the ash passing out of the melting chamber and over the slag pocket previously referred to.

every four weeks. There is consequently no saving in using a cheap coal, particularly in times of great demand for steel. The gain due to the avoidance of frequent shut-downs pays several times over the difference in the price of coal."

Fig. 22 shows the application of powdered coal to a steel tilting furnace. It will be noticed that it is a furnace of the non-reversing type, the flow of the gases being always in one direction, which simplifies the installation, and incidentally it may be pointed out that the use of powdered coal enables the gas regenerators to be dispensed with. The figure has been taken from Mr. C. J. Gadd's paper previously referred to.

With regard to sulphur contamination of steel, this is no greater than with producer-gas. The sulphur contained in the coal is split up into such fine particles that it is immediately burned and the products pass off in the waste gases. In one case a coal containing 1·25 per cent. sulphur was used, and the analysis showed only 0·035 per cent. to 0·04 per cent. in the steel produced.

Several figures relating to fuel consumption when using powdered coal are given in the "Report," the average being between 500 lb. and 600 lb. per gross ton of ingots cast. Reference may be made to certain results obtained in one instance, after conversion of a producer-gas-fired open-hearth furnace to pulverised coal firing; record monthly tonnages were obtained, and for 3,218 tons melted in one month the overall fuel consumption was 441 lb. per gross ton of steel.

Soaking Pits.—A powdered-coal-fired soaking-pit, fitted with a combination high and low pressure syphon burner, is shown in Fig. 23 on the preceding page.

This illustration has been taken from Mr. C. J. Gadd's paper previously referred to.

Puddling Furnaces.—Fig. 24 shows a very common type of puddling furnace fitted with waste-heat boiler and air-heating pipe. Fuel-consumption figures obtained on furnaces making special muck bar for stay bolts, both with cold and pre-heated air, are given under "Results," page 164. It may here be mentioned that with air pre-heated to 532 deg. F. (280 deg. C.) and with cold air 62 deg. F. (17 deg. C.) a reduction of about 10 per cent. in fuel consumption due to the hot-air supply is obtained. Melting times, &c., were as follows:—

Period of operation, 4.30 a.m. to 2.38 p.m.		lb.	
Total iron charged ...	...	5,028	
Total iron puddled ...	...	4,502	(4 heats of 1,125 lb.)
Loss of metal in furnace ...		526	

Time of individual heats, 1 hour 50 minutes to 2 hours 15 minutes.

Some very valuable features of powdered-coal firing for puddling furnaces are evidenced by the records of gas analysis taken during the various operations. The charts (Fig. 25) show that perfect combustion, reducing, or oxidising conditions can be obtained at will, whereas with hand-firing such flexibility of control is impossible. These charts were specially made to find out from actual gas analysis the precise advantages in this direction which are directly attributable to powdered-coal firing as against hand-firing.

Fig. 26 shows a standard type of three-door heating furnace, fitted with waste-heat boiler and air-heating pipe. Furnaces of this design are generally used in America for heating iron piles, &c., and a number of such furnaces were seen in use for this purpose and for heating slabs for rolling.

Average charges for three-door furnaces serving 8 in. by 12 in. tandem mills were 80 pipe piles 4 in. by 4 in. by 24 in. The average temperature of furnace at commencement of drawing the charges was 2,560 deg. F. (1,400 deg. C.), the average times for the cycle of operations were: charging, 0 minutes; heating, 50 minutes; drawing, 1 hour 15 minutes.

Blast Furnaces.—In this connection the use of pulverised coal is not new, experiments having been carried out very many years ago with little success.

It is, however, interesting to quote verbatim a description of a recent report upon a proposed method of using coal for this purpose in Germany.

F. Lange* states that at the Phœnix Works at Kupferdreh from 4 per cent. to 8 per cent. by volume of lean and anthracite coal from a neighbouring mine was mixed with the iron-ore charge This addition of raw coal was always found to have a good influence in the production of foundry iron, hæmatite, and ferrosilicon, and particularly on the silicon contents of metal. A similar addition is also to be recommended in the production of ferro-manganese, especially when brown ore is used that contains the manganese as the higher oxide. Also the coke can be partly replaced by lump anthracite with a saving in cost depending on the prices of the materials.

Another use of raw coal is its introduction through the tuyeres directly into the furnace, but in a dry and very finely powdered condition, so that not more than 16 per cent. remains behind on a 180-mesh screen. This use of raw coal is believed by Lange to have a good future. In order to introduce successfully a part of the fuel at the tuyeres it is absolutely necessary that a sudden and intensive combustion should take place, which can only be brought about by the greatest possible fineness of the coal. The temperature in the melting zone will be considerably increased, and the following advantages are to be expected:—

1. The cost for fuel will be smaller, because the coke is partly replaced by the much cheaper coal. At Kupferdreh, if one-sixth of the coke were replaced by the dry-powdered coal the saving would be 1·25 marks per ton of pig iron.

2. The production of ferro-silicon, ferro-manganese, ferro-chrome, &c., will be made easier, and with ferro-manganese there will be less loss of manganese in the slag.

3. The top temperature will be lower, because less fuel will be added with the charge.

The influence of the fine coal may be compared with that of an increased blast temperature, because its effect is developed directly at the tuyeres. Its use is particularly recommended for small blast-furnaces, which are preferable when fine ores are to be used. On account of the heat developed by the coal the blast temperatures could be lowered so that the old pipe stoves would be preferable, on account of the regularity of temperature thereby obtained.

It is pointed out in conclusion that the powdered coal provides a suitable means of heating the stoves when starting up or when the gas supply is insufficient for any reason.

On this subject the author has received some valuable notes from Mr. Wotherspoon of New York, who kindly gives permission for reference to be made to this information.

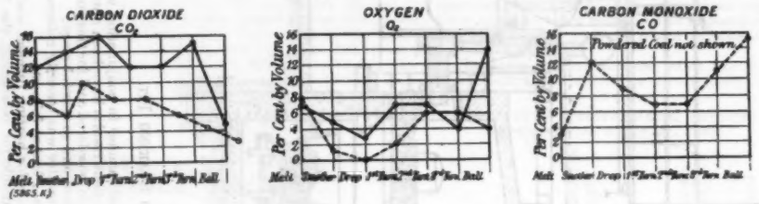
Mr. Wotherspoon says that there is one important development in the use of pulverised coal of special interest, namely, the use of it in blast-furnaces for the smelting of non-ferrous ores.

A company has just been formed in New York to work patents covering the processes of smelting by pulverised fuel. The novelty is the combustion of pulverised fuel under pressure in the restricted combustion space contained in a blast-furnace charge, which space consists of the voids in the charge, that is, in the ores, fluxes, and by-products, and in the channelling in the smelting zone.

* *Stahl und Eisen: Iron Age*, September 2, 1915.

Fig. 25. PUDDLING FURNACES. FLUE GAS ANALYSES.

Powdered Coal Firing ——
Hand-Stoking - - - -



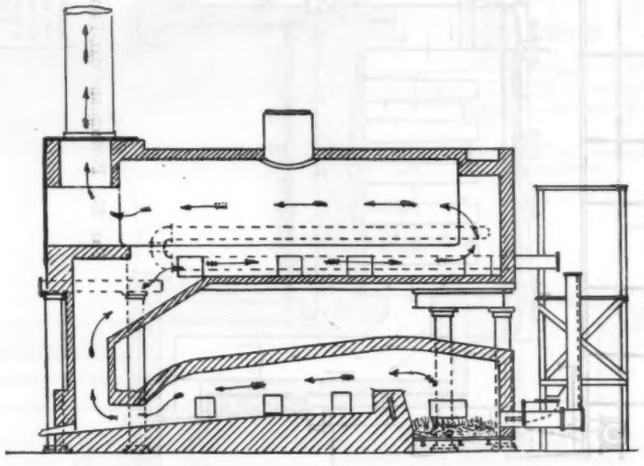
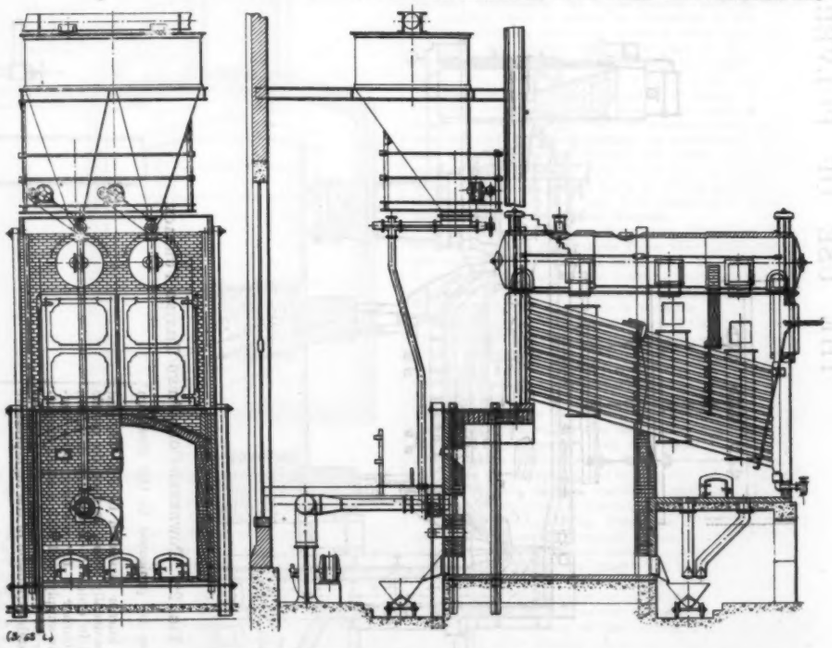


FIG. 26. POWDERED-COAL-FIRED SLAB HEATING FURNACE.

Fig. 27. 500 H.P. BABCOCK & WILCOX BOILER ARRANGED TO BE FIRED WITH PULVERISED COAL



At Tennessee a furnace has been operating for some time with all the coke replaced by pulverised coal, and it has been found that the percentage of powdered coal required is 3·8 per cent. as against 6 per cent. or more of coke in ordinary practice, thus showing not only very important economies due to the substitution of a cheap fuel for an expensive one but also a reduction of about 30 per cent. in tonnage required.

At the International Nickel Company's smelter works extended runs have also been made with the coke reduced to one-half, the deficiency in fuel being made up by pulverised coal.

Nodulising Iron Ore.—Iron ore is nodulised in kilns of similar design to those used for burning cement; the high temperature produced by combustion of coal dust renders this method of heating very successful for nodulising iron ore, in which form it can be charged into blast-furnaces with a minimum of loss.

Boilers.—This subject has been fully treated in the Report submitted to the Director of Fuel Research, but it will not be out of place to record here the views of Professor W. F. Durnand,* Leland Stanford University, California:—

"To obtain the best results in the furnace the coal should be ground to a degree of fineness which will ensure the passage of 95 per cent. through a 100-mesh screen and 85 per cent. through a 200-mesh screen.

"With coal thus prepared and with heating value 11,580 British thermal units, tests have shown an equivalent evaporation of 8·38 lb. per pound of coal fired, and of 10·9 lb. per pound of combustible. With Texas lignite with a heating value of 11,250 British thermal units the results showed 7·26 lb. per pound of coal fired and 8·81 lb. per pound of combustible."

These remarks were made in relation to the possibility of firing boilers with Texas lignite carrying as high as 20 per cent. ash and 30 per cent. moisture, and the results are indicative of what can be accomplished with low-grade fuels for this purpose.

In connection with copper-smelting furnaces, waste-heat boilers are invariably used, and it has been stated that, as compared with hand-fired furnaces, boiler tubes are cleaned no oftener when using pulverised coal than for hand-firing. The ash in the waste gases gives very little trouble, flue connections being cleaned out once a day. With certain coals less trouble has been experienced in cleaning away the ash in flues with a 20 per cent. ash coal than with a coal containing only 9 per cent. of ash but of a more fusible nature. Approximately 50 per cent. of the total ash content remains in the furnace and is run off in the slag.

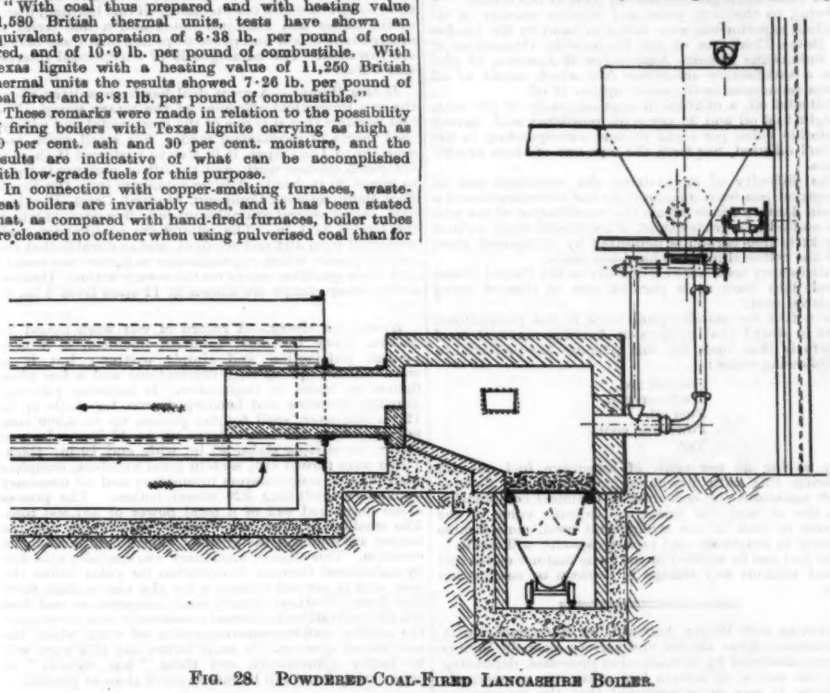


FIG. 28. POWDERED-COAL-FIRED LANCASHIRE BOILER.

An illustration in the "Report" shows the arrangement of a Dutch oven built out in front of the boiler and the provision of slag chamber that is to be preferred in cases where an ash-pit of the design shown can be used. It is essential to provide a sufficient combustion area per pound of coal burned per minute or per hour, otherwise incomplete combustion results, and ash is not deposited in the slag chamber in the quantity required. An undesirable deposit will also be found on the boiler tubes, due to the partly burned particles of coal adhering to the tubes and fluxing thereon, and to the high velocity of gases through the restricted combustion chamber. This results in the carrying over of an undue proportion of the ash.

With correct combustion space and low velocity of gases readily fusible ash is deposited in the slag chamber, and the fine more or less infusible particles float through the boiler tubes and boiler passes.

In cases where it is impossible to excavate under the boiler setting to provide for the slag chamber, or for the ash tunnel, an extended Dutch oven must be employed to obtain the required minimum combustion area.

The ideal conditions exist, of course, when a new plant is to be designed. Fig. 27 shows the latest approved arrangement. All burner and air-supply piping is out of the way in the ash tunnel, and ample provision can be allowed for the ready handling of the slag deposit and fine dust removal.

Applications to Lancashire boilers are not so easily carried out when space in front of the boiler is limited. A suitable arrangement, having in mind the essential points mentioned above, would be that shown in Fig. 28.

The ideal arrangement would be to have a deep and narrow combustion chamber in front of the boiler with a burner at each end, but Lancashire settings are as a rule so close that this method cannot be adopted.

Waste-Heat Boilers.—The application of powdered fuel to high-temperature furnaces, open-hearth melting, puddling, forging and welding, billet-heating furnaces, with the exception of those of the continuous type, and cement kilns makes it possible to instal waste-heat boilers with great advantage. The temperature variation in such furnaces is very small, comparing favourably in this respect with the uniform temperatures obtainable with gas and oil firing. The fine unfused ash dust passing into the boiler from the furnace causes very little inconvenience.

The utilisation of waste heat from metallurgical furnaces was very fully dealt with by T. B. Mackenzie* at the last meeting of the Institute, and heat balance-sheets and results of tests will be found in his paper. A. D. Pratt† has also recorded the results of tests of waste-heat boilers attached to open-hearth furnaces.

By the use of a supplementary burner fitted at the uptake to the boiler, steady steaming at full rated output can be obtained, thus removing the usual objection to this type of steam supply plant.

Locomotives.—The work that must be carried out in order to convert hand-fired locomotives to powdered-coal firing is not excessive, and the equipment is not at all complicated; for instance, the Fuller apparatus has been designed with reliability and simplicity as the two outstanding features. For this system, as a rule, standard brick arches are used. The burners are made as large as possible, so that velocity of the entering coal-dust mixture is low, which eliminates a cutting flame and damage to the refractory brickwork. The two screw feeders are geared to a slow-speed, two-cylinder reciprocating engine. Either burner can be used for maximum feed should this be necessary. The feeder engine can be run off the round house steam supply until 15 lb. locomotive boiler pressure is developed and will run under all pressures from 15 lb. to 200 lb. per square inch. 300 per cent. feed regulation can be effected from the cab control and 600 per cent. by shifting over the gear-control lever. A steam turbine fan is used to supply air at 2-inch (w.g.) pressure.

The application of pulverised coal to colliery locomotives should be of considerable value, thereby rendering possible the burning of low-grade coals, which may be unsuitable for sale as commercial fuel.

It can be taken that at least 20 per cent. to 30 per cent. of coal tonnage now required for hand-fired locomotives can be saved.

Diagram Fig. 29 shows a comparison of the fuel losses in locomotive boilers, when hand-fired and when using powdered fuel.

Marine Propulsion and Internal-Combustion Engines.—Reference to the trials conducted on United States Scout Patrol Ship Gem with powdered coal has been made in the "Report." During these trials it was demonstrated that equal speed could be obtained with steam generated in one boiler fired with powdered coal as with two oil-fired boilers. At the same time a CO_2 content of 14 to 16 per cent. was maintained when using coal dust.

There is an extremely important field for investigation in this direction, and it may eventually become possible to pulverise and use ordinary bunker lump coal without having to rely upon shore pulverisation and the bunkering of coal in powdered form.

Very successful trials have been run over extended periods on a cruiser under war conditions during the past two years, one boiler having been fired almost exclusively with powdered coal.

Another question now receiving attention is the supply of powdered coal and air as an explosive mixture for internal combustion engines. Much work has been done already in America, and difficulties with deposit and cutting of engine valves have been to a very great extent overcome. This method of power development is destined to become of increasing value in the future.

LIGNITE, PITCH AND COLLOIDAL OIL AS FUELS FOR METALLURGICAL PROCESSES.

Lignite.—Lignites are soft and readily ground, so that mill output is increased as compared with the rates for grinding anthracite or bituminous coals; power per ton ground is correspondingly reduced. Apart from the necessity of drying slowly, owing to the heavy moisture content which reduces the capacity of dryers, lignite is an excellent fuel where sulphur contamination is to be avoided, for it contains little or no sulphur as a rule, and the more or less infusible ash is easily removed from combustion chambers or flues.

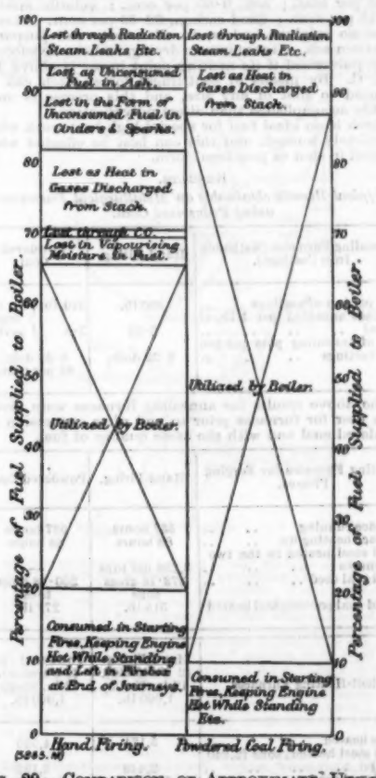

Lost through Radiation, Steam Leaks Etc.
Lost as Unconsumed Fuel in Ash.
Lost in the Form of Unconsumed Fuel in Cinders & Sparks.
Lost as Heat in Gases Discharged from Stack.
Lost through C.O.
Lost in Vaporising Moisture in Fuel.
Utilised by Boiler.
Consumed in Starting Fires, Keeping Engine Hot While Standing and Left in Firebox at End of Journeys.
Percentage of Fuel Supplied to Boiler.
Hand Firing.
Powdered Coal Firing.

FIG. 29. COMPARISON OF APPROXIMATE UTILISATION AND WASTE OF FUEL SUPPLIED TO A LOCOMOTIVE BOILER WITH HAND AND POWDERED COAL FIRING, TAKING FUEL AS DELIVERED TO ENGINE TENDER.

The following is an account by Mr. W. H. Maddocks, of the M.K. and T. Railway, regarding the first tests ever made with powdered lignite for firing boilers. The tests were run on some of the O'Brien boilers fitted with Fuller Engineering Company's equipment. "Hoyt Texas, lignite as tested gave the following analysis:—

	Wet. Per cent.	Dry. Per cent.
Moisture	24·49	7·06
Volatile	38·17	54·52
Carbon	28·94	24·72
Ash	8·41	13·70
	100·00	100·00
Sulphur separately determined	0·53	0·098
British thermal units... ...	7,996	10,675

"Five car-loads of this coal have been used under various conditions. Two of them had been exposed to heavy rains and showed 46 per cent. moisture. With our limited dryer capacity the coal was repassed, and when finally used showed moisture varying from 7 per cent. to 13 per cent. Coal burned under these con-

* *Electrical World*, January 6, 1917.

* *Journal of the Iron and Steel Institute*, 1918, No. II., page 139.

† *Journal of the American Society of Mechanical Engineers*, December 6 1916.

ditions gave good results, no slag, and under high forcing of the furnace an evaporation of 7·33 lb. to 8·8 lb. from and at 212 deg. per pound has been obtained with this low B.t.u. value. No choking of screens occurred in milling at this moisture content, but it is believed the limit was about reached.

"The average fineness was 93 to 94 per cent. through 100-mesh and 84 per cent. to 86 per cent. through 200-mesh screen; this with a moisture of 7 per cent., not quite so good with 13 per cent. moisture. Quantity milled was in excess of bituminous coal. One car was unloaded in November, 1916, and the coal was stocked and used the following summer. This was dried, milled and used with no appreciable loss.

"With a dryer designed for this coal with its excess of moisture it could be burned equally as well as bituminous and with less deterioration on furnace refractories due to non-slagging."

Pitch.—Pitch as a fuel has valuable characteristics, and is burned in a liquid state in the manner described in the "Report."

It can also be burned as a pulverised fuel; for obtaining this in powdered form special mills must be used, and only hard pitch having high melting points can be successfully treated in this manner. An analysis of hard pitch shows* that its calorific value can be as high as 15,928 British thermal units per pound; moisture 0·05 per cent.; ash, 0·60 per cent.; volatile matter, 66·85 per cent.; fixed carbon, 32·55 per cent. It contains no sulphur, and is, to all intents and purposes, free from ash. It requires no drying, and can be successfully pulverised if its melting point in air is above 150 deg. C. By means of centrifugal force, pitch can be reduced to shot of any size, and this process is more readily accomplished than direct pulverisation.

Pitch is an ideal fuel for special high-heat work when completely burned, and this can best be effected when applied in shot or powdered form.

RESULTS.

Typical Results obtainable on Metallurgical Furnaces using Pulverised Coal.

Annealing Furnaces (Malleable Iron Castings).	Hand-Firing.	Powdered Coal.
Coal per ton of castings ..	880 lb.	340 lb. } 61 per cent.
Castings annealed per 1 lb. of coal	2·25	5·8 } saving
Cost of annealing pots per ton of castings	2·25 dols.	0·83 dols. 63 per cent.

The above results for annealing furnaces were given by a user for furnaces prior to and after conversion to powdered coal and with the same quality of fuel.

Heating Furnaces for Forging Presses.	Hand-Firing.	Powdered Coal.
Furnace running	537 hours	537 hours
Furnace heating up	88 hours	88 hours
Total steel heated in the two furnaces	3,238 net tons	—
Total coal used	373·16 gross tons	200·18 gross tons
Pound coal per ton steel heated	515 lb.	277 lb.

Shell-Heating Furnaces.	Hand-Firing (2 Furnaces). 12-in. Shells, 1,060 lb.	Powdered Coal (1 Furnace). 12-in. Shells, 1,060 lb.
Shells heated	5,174	4,505
Total steel heated, tons (2,240 lb.)	2,449	2,132
Total coal used	726,630	343,275
Pounds coal per ton steel ..	296	161

Open-hearth furnace :—
500 lb. per ton of steel, as against 800 lb., with gas-producers using the same grade coal and for the same composition of steel.

Performance of open-hearth furnace, June 13, 17, 1916 :—

Heat No.	Time.	Tons Ingots.	Pulverised Coal per Ton Ingots.	Total Coal per Ton Ingots.	Pulverised Coal per Hour.
	hr. min.				
3,327	9 40	39·913	661	685	2,730
3,328	10 15	49·554	542	561	2,620
3,329	10 55	47·764	558	578	2,440
3,330	10 20	46·929	539	558	
3,331	9 10	47·571 (average)	(average)	(average)	2,615
3,332	9 20	45·475	550	569	2,710

Puddling furnaces :—
Hand-fired, 2,200 lb. to 3,300 lb. per ton of iron.
Pulverised coal, 1,200 lb. to 1,600 lb. per ton of iron. Summer months, two turns.
Air pre-heated 500 deg. F.
Average coal consumption, 1,230 lb. per ton of iron operating in cooler months on three turns.

Heating furnaces :—
Hand-fired, 900 lb. per ton of iron reheated.
Pulverised coal, 550 lb.
For 12-in. rolling mill. Average, 535 lb. coal per gross ton steel for 16-in. rolling mill. 518 lb. coal per gross ton steel.

Continuous heating furnace :—
Steel billets, 5 in. by 7 in. by 14 ft. long.
Hand-firing, 220 lb. per ton.
Pulverised coal, 168 lb. per ton.

Bushelling furnace for 16-in. mill :—
Average, 542 lb. coal per gross ton steel.

Faggotting furnace for 16-in. mill :—
Average, 530 lb. coal per gross ton steel.

Medium forge furnaces :—
When heating blooms 10 in. thick by 18 in. wide and 15 ft. long, the coal consumption with hand-firing was 650 lb. per hour, and with pulverised coal 350 lb., and at the same time the furnaces gave a 20 per cent. increased output when fired with powdered coal.

Furnace for wrought-iron welding :—
Pipe skelp heated by means of pulverised coal of 14,000 British thermal units value, 275 lb. to 300 lb. per gross ton of iron welded.

Furnace for heating wrought iron :—
Muck bar piles, 640 lb. to 720 lb. of coal per gross ton of bar produced.

Ore Smelting.

Zinc-copper ore in reverberatory furnaces.
Hand-firing, 40 tons to 50 tons of coal used for smelting 30 tons of ore—say, 150 per cent. fuel consumption.
Powdered-coal firing, 30 tons of coal used for smelting 90 tons of ore—33⅓ per cent. coal consumption.
Saving 116 tons of fuel per ton of ore smelted.

Colloidal Oil.—This fuel is a product of the war, and original experiments in its manufacture and application having proved a success, it is quite likely that it will find a place amongst commercial fuels of the future.

Owing to the high price and relative scarcity of oil supplies, experiments were taken in hand by Mr. Lindon W. Bates, Chairman of the Engineering Committee of the Submarine Defence Association of America, to produce a satisfactory substitute fuel which would at all events economise in the consumption of oil.

Colloidal oil, a mixture of approximately 70 per cent. straight fuel oil and 30 per cent. powdered coal, having a calorific value per equal volume corresponding to the original oil used, has been the outcome of these experiments.

The difficulty of maintaining the powdered coal in suspension has been overcome by the incorporation of a certain fixative which effects the combination of the coal dust and oil to a great extent in a colloidal state, so that very little free carbon is deposited by settlement when once the colloidal mixture has been made.

Satisfactory tests were carried out on the United States Patrol Ship Gem as a parallel test to that of using powdered coal.

As a fuel for metallurgical work it has possibilities, for it is stated that opinion in America amongst steel melters is that fuels for this purpose are preferred in the following order :—

Natural gas.
Producer-gas.
Fuel oil.
Powdered coal.
Tar.

By saving 30 per cent. of expensive fuel oil and replacing this with powdered coal plus the fixative which maintains the coal dust in chemical combination with the oil and also raises the calorific value of the mixture to that of the straight oil used, considerable economy in freightage and tanker capacity will result.

The fuel can be applied in the same manner as for fuel oil and without any change of burners or combustion areas.

ACETONE AND BUTYL ALCOHOL BY BACTERIOLOGICAL PROCESSES.—Since alcohol and various alcoholic liquors are manufactured by fermentation processes, depending upon the action of certain low organisms as energetic catalysts, it was to be expected that the preparation of acetone and butyl alcohol, valuable solvents, by similar processes would be attempted. There was, indeed, considerable activity in this field after 1908, when the preparation of artificial rubber excited much attention. A product very much like rubber can be obtained by the polymerisation of butadiene or isoprene, and acetone and butyl alcohol are the primary reagents of these processes. A. Fernbach isolated an organism which fermented potato starch into acetone and butyl alcohol. After the war had broken out, C. Weizmann, working in the Biochemical department of Manchester University, found in maize a cheaper raw material, and he was able to run a plant of 5 galls. of mash continuously. When the process was tried on a large scale at the Naval Cordite Works at Poole and elsewhere, however, difficulties crept in, partly owing to the lack of suitable plant, and a good deal of mash was wasted. But successful processes were worked out in England, in the United States and in Canada, also in Germany, it would appear. In the Journal of the Society of Chemical Industry, of June 30 last, pages 155 to 61, Horace B. Speakman, M.Sc., describes in detail the process developed in the Department of Zymology of the University of Toronto. He deals entirely with technical features, and does not even mention the name of the organism with the culture of which he inoculates his mash. The chief points seem to be: the mash has to be prepared carefully and rendered homogeneous; it must be sterilised before inoculation (to kill other bacteria) in vessels capable of bearing steam pressures of at least 10 lb. per sq. in.; the mash must be cooled quickly, and under aseptic conditions, to the fermenting temperature, and be fermented in sterile vessels; and all pipes through which the mash passes must be kept sterile. The cooling from 216 deg. F. down to about 100 deg. F. takes two and a half hours, instead of the nine hours originally allowed. The fermenters used have a capacity of 24,000 galls., and are charged from a cooker of 6,000-galls. capacity. Since April, 1916, when the plant was started at Toronto, till armistice time, none of the 3,458 inoculated fermenter-charges had to be turned into the drains.

CATALOGUES.

Water Heaters.—A few water heaters, in which the feed water passes through helically-coiled tubes which are acted upon by steam in an enclosed vessel, are illustrated and described in a catalogue issued by the Griscom-Russell Company, 90, West-street, New York. Another catalogue deals with "distillers," which, in this case means a condenser and cooler only, in which steam from an evaporator passes through similar tubes, and is acted upon by cooling water in a similar vessel. The work and material is very much alike in these and about 20 other heating, cooling, separating and filtering appliances, and all are produced by this company on a well-organised manufacturing system. The design of vessels, pipe joints, &c., are satisfactory.

Marine Boilers.—The oil-fired water-tube boiler in its latest and best form is shown in a catalogue issued by Messrs. John I. Thornycroft and Co., Limited, Woolston, Southampton. The triangular arrangement bids fair to prove permanent. The two lower (water) drums are about half the diameter of the upper (steam) drum. The tubes bend at the lower ends and enter straight into the steam drum. The various preceding arrangements and forms are illustrated in the catalogue, which also contains sections on the history of the water-tube boiler, care and maintenance, oil fuel burning, many useful tables and technical notes and a fine series of illustrations of war and peace ships in which these boilers are installed. The catalogue is of exceptional interest and value.

Rotary Pumps.—A great deal has been written about the low theoretical efficiency of the rotary pump. The fact remains that it is one of the most useful and widely-used pieces of mechanism made. For small pipes, and even up to 1-in. pipes, it is always preferred if there is not much suction work, and the lift or pressure is equal to about 20 ft. head. A little catalogue from the Brook Tool Manufacturing Company, Limited, Greet, Birmingham, shows several examples made in five sizes, of which the largest is 1 in. The pumps are so compact, well protected from dirt and accident, and so durable that the driving power, which approximates to 0, does not count; and these qualities centre on the rotary action. Double-acting wing pumps are shown in 12 sizes from ¼ in. to 3 in.

Heavy Machinery.—A record of war work issued by Messrs. Davy Brothers, Limited, Sheffield, is a very modest publication and simply written; but it is work which requires only illustrations and a few plain figures to make it impressive. It includes piercing, drawing, pointing and bending presses for shells up to 12 in. diameter, shell forging presses up to 6,000 tons power, rolling mills for plates up to 40 in. wide, and shears for cutting slabs, 40 in. wide and 10 in. thick. These were turned out, each in great numbers, complete with pumps, accumulators intensifiers and all necessary appliances, including 220 steam boilers. The presses alone numbered 642 of a total power of 357,500 tons. The smallest of these are "heavy" machinery and the largest are amongst the greatest monsters of mechanical creation. This class of machinery was specially attacked by subsidised German competition for years before the war, and it proved fortunate for the nation that firms like Davy Brothers fought that competition and had the skilled staff and material resources in reserve to meet the sudden and immense expansion of work which the war forced upon us. In some future day this work will be better appreciated, and these "war records" of engineering firms will be more valued than at present.

AMERICAN SHIPBUILDING.—According to *International Marine Engineering*, the report of the United States Shipping Board Emergency Fleet Corporation shows that in April last there was a total delivery of 111 ships, aggregating 368,476 gross tons, or 543,720 deadweight tons. In April, 1918, the total delivery was 31 ships, aggregating 114,274 gross tons, or 171,413 deadweight tons. In May last, the total delivery increased to 136 ships, of 511,074 gross tons, or 768,025 deadweight tons, as against 43 ships of 169,608 gross tons, or 254,413 deadweight tons in May, 1918. The report shows that contract steel ships constituted the great bulk of deliveries for April and May.

GAS MASKS IN INDUSTRIAL USE.—From a publication by A. C. Fieldner, M. C. Teague and J. H. Yoe, of the United States Chemical Warfare Service, in the *Journal of Industrial Chemistry* of July, we see that the "standard Army filling" answered on the whole best as a protection against obnoxious industrial gases. This standard filling consists of 60 per cent. of charcoal and 40 per cent. of "purple" soda lime (granulated to from 8 to 14 mesh), and the canister contains 42 cub. in. of the intimate mixture. While not quite so effective as either charcoal or soda lime alone in cases where only one of the constituents acts as absorbent, the standard mixture can in general be recommended, especialy also for chlorine, phosgene, the tetrachlorides of tin, silicon, titanium, nitrogen peroxide, chloracetone, benzyl bromide, &c., charcoal alone would be preferable for gasoline, benzol; carbon disulphide, carbon tetrachlorate, cyanogen bromide and similar vapours which are not absorbed by soda lime; whilst sulphur dioxide, carbon dioxide, prussic acid, hydrogen chloride and sulphide and most acid gases are best taken up by soda lime. In the case of smoke particles and the hydrolysis products of stannic chloride, arsenictri oxide, &c., the canister should contain two cotton wads. Ammonia, carbon monoxide, natural gas and coal gas, blast-furnace gas and the so-called permanent gases (oxygen, hydrogen, nitrogen) are difficult to arrest.

* *Power*, June 25, 1918.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

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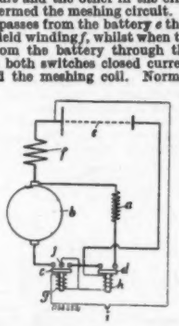
ELECTRICAL APPARATUS.

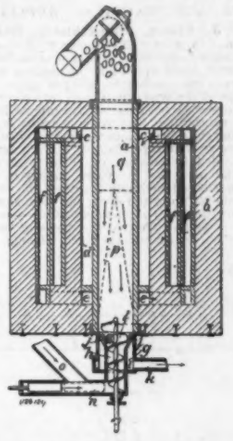
126,253. H. Lucas, Birmingham, and H. W. F. Ireland, Birmingham. Electric Starting Motors. (2 *Figs.*) December 19, 1918.—In some types of electric motors used for engine starting purposes on mechanically-propelled vehicles, a pinion driven by the motor is normally out of mesh with a wheel or pinion through which motion is transmitted to the engine. The object of the present invention is to construct an improved twin or double switch controlled by a single movement of the operator and adapted to automatically provide a sufficient delay or "time-lag" between the actions of the two switches to ensure proper engaging of the motor-driven pinion. The invention comprises the employment of a pair of switches in conjunction with a pair of solenoids (one solenoid for each switch), the solenoids being inter-connected in a circuit controlled by a push button or other switch which is actuated by the operator, and the switches so constructed that the solenoid of one of them is put out of action by the closing of the other switch. In the application of the invention to a system in which a "screw-in" pinion is held against rotation magnetically or frictionally during the pinion meshing operation, and in which the winding *a* of the pinion meshing device is in parallel with the armature *b*, a pair of switches *c* and *d* are employed, one in the motor circuit and the other in the circuit which for convenience will be termed the meshing circuit. When the switch *d* is closed, current passes from the battery *e* through the meshing coil *a* and motor field winding *f*, whilst when the switch *c* is closed current passes from the battery through the armature *b* and winding *f*. With both switches closed current divides between the armature and the meshing coil. Normally each switch is



opened and held open by a spring. In conjunction with each switch is a solenoid *g*, *h*, acting on a plunger by which the switch is closed. The two solenoids are connected in series with each other and with the battery and a push-button switch *i*. The motor switch is provided with an additional contact *j* connected to the solenoid *h* of the meshing switch in such a manner that when the motor switch is closed the said solenoid is short-circuited. The two switches may operate simultaneously, but preferably the meshing switch *d* is closed slightly before the motor switch *c*. This may be effected by providing the meshing switch with a rather weaker spring or a smaller air gap in its solenoid than the other, or any other delaying device may be used. On closing the push-button switch *i* both solenoids are excited, and either simultaneously or in succession the two switches are closed. With both closed current flows through both the motor and the pinion meshing device. With the closing of the motor switch and the consequent short-circuiting of the meshing switch solenoid the meshing switch does not immediately open, but for an interval depending on the time constant of the short-circuited solenoid is held closed. During this interval the pinion moves into its operative position. Subsequently the motor switch alone is in action, and this remains closed during the starting operation, so long as the operator keeps the push-button switch closed. Opening of the motor switch occurs when the push button is released. It will be understood that any desired delay can be obtained in the opening of the meshing switch by suitably proportioning its time constant on closed circuit. (*Accepted May* 14, 1919.)

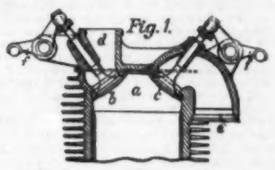
GAS ENGINES, PRODUCERS, HOLDERS, &c.

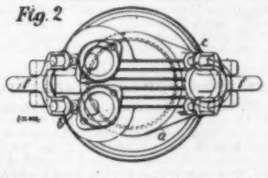
126,121. F. J. Bancroft, New Barnet, and J. B. Hansford, New Barnet. Gas Retorts. (1 *Fig.*) April 27, 1918.—This invention relates to gas retorts of the continuous or intermittent vertical type, wherein the coal is charged into the lower end of the retort, and forced therethrough in an upward direction by a power-actuated device, the gases being drawn off from the lower end of the retort. The invention consists in an improved method of working such retorts, the object being to promote high gas, tar, tar oils and by-product yields, and coke of good quality. In working the above type of retort, according to this invention, definite quantities of air, and steam or water, are introduced into the top of the retort. The air and steam pass down the retort, and at the hottest zone combustion takes place, the temperature considerably increasing, whereby the well-known water gas reaction takes place from the steam admitted. The hot gases thus generated descend through the retort and through the incoming coal, giving up their heat and assisting carbonisation, and pass to an exit or exits in the bottom of the retort which is the coldest zone within the retort. *a* is the retort casing. The casing is arranged in setting *b*. The retort is heated by gas admitted through inlets *c* in the upper part of the retort into a combustion chamber *d*. Products of combustion pass from this chamber through outlets *e* into a regenerator *f*. The retort surmounts a casting *g* which embodies a passage *h* for the introduction of carbonaceous material into the bottom of the retort and a chamber *i* encircling that passage, and into which gas is drawn down through the material freshly fed in and through the openings *j*. The evolved gas and other substances are withdrawn from chamber *i* through the conduit *k*, which is connected with the fitting *g*. The means utilised for feeding carbonaceous material into the bottom of the retort and forcing it upwardly therethrough, comprises a rotatable screw conveyor *l* axially disposed within chamber *h*. Extending laterally from the chamber *h* is a passage *n* into which the carbonaceous material is fed through a hopper tube *o*. The broken lines *p* indicate the uncarbonised mass of material in the retort, such mass partaking



a more or less conical shape, the apex of the cone extending towards the hottest zone *q* in the upper part of the retort. The outer portions of the uncarbonised conical mass which are nearest the walls of the heated retort become carbonised first. The hot gases which are drawn off eventually through conduit *k* pass down through the uncarbonised mass and thereby assist in the carbonisation. (*Accepted May* 14, 1919.)

126,008. J. D. Siddeley, Coventry. Internal-Combustion Engines. (5 *Figs.*) October 3, 1916.—This invention relates to internal-combustion engines of the type having a plurality of radially-arranged air-cooled cylinders. According to the present invention, each cylinder is provided with a plurality of valves which are arranged in inclined positions in the head of the cylinder at suitable angles in relation to the longitudinal axis of the engine, the exhaust valves being arranged at the

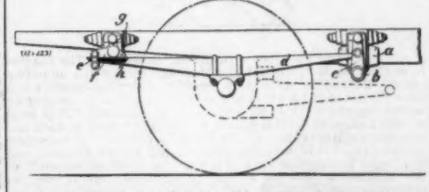




front of each cylinder and the inlet valves at the rear thereof. *a* designates the head of the cylinder, *b* the exhaust valve, *c* the inlet valve, *d* the exhaust passage, and *e* the inlet passage. The valves are all arranged in the head *a* of each cylinder in inclined positions, and are operated by tappets *f* in the usual manner. The exhaust valves *b* are in all cases arranged on the front sides of the cylinders so as to obtain the maximum cooling effect from the passage of the engine through the air. (*Accepted May* 14, 1919.)

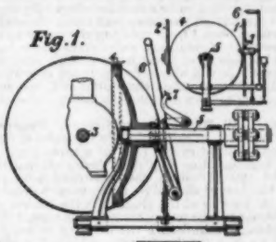
MOTOR ROAD VEHICLES.

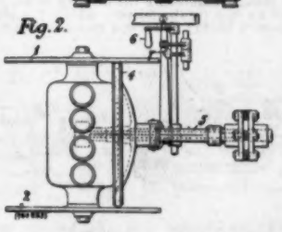
125,223. The Birmingham and Midland Counties Transport Company, Limited, Birmingham, and G. E. D. Ralls, Birmingham. Spring Mountings. (1 *Fig.*) April 12, 1918.—This invention comprises a spring mounting for a motor or other vehicle of the kind in which the wheels are coupled to the chassis by rods which are separate from each other and disposed one on each side of the vehicle, said rods permitting movement of the wheels longitudinally of the vehicle against the resistance of resilient media, and in which the said rods are at their extremities remote from the wheel axis constrained in such movement



to operate in unison so that the said movement occurring on one side of the vehicle coincides with that occurring on the other side of the vehicle. According to the invention, in this type of spring mounting the rods which are disposed one on each side of the vehicle, and which permit of movement of the wheels longitudinally of the vehicle against the resistance of resilient media, comprise the spring suspension means by which the wheels are coupled to the chassis. Accordingly, the said spring suspension means consisting, for instance, of laminated springs are coupled at one or both extremities to a lever, the movement of which is controlled by a spring or springs, and which lever is constrained to operate in unison with a similar lever occurring on the other side of the vehicle. The springs controlling the movement of the said lever operate between the said lever and a fixed part of the chassis. Secured to the chassis in the vicinity of the extremity of a laminated spring carrying a wheel axle, is a bracket *a* having at its lower extremity a bearing for a shaft *b*, extending transversely across the vehicle to a similar bracket on the other side of the chassis. This shaft carries at each end an upwardly-extending lever *c*, and said lever is controlled at the top by a plurality of resilient elements incorporated in opposed relationship to each other. The extremity of the laminated spring *d* is coupled to the upwardly projecting lever *c* at a position between its axis of movement and its extremity, which is controlled by the resilient elements. The rear extremity of the spring *d* projects through a shackle *e* provided upon a bell-crank lever *f*, an upwardly-extending arm *g* of which is controlled by opposed springs *h* which may operate in manner similar to the springs which control the arm *c*. The bell-crank lever *g* carries a bearing portion *h* adapted upon the spring *d* being excessively deflected, to come into contact with the latter at a position nearer to the wheel axis. (*Sealed.*)

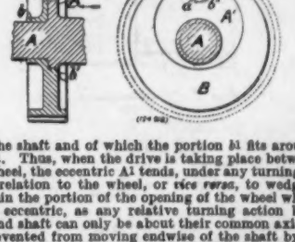
124,955. G. Taylor, Penrith. Variable-Speed Gear. (3 *Figs.*) May 28, 1918.—This invention relates to an infinitely variable speed gear applicable to motor vehicles of the type comprising a pair of driving discs rotatable in the same direction around a common axis and a driven disc rotatable on an axis transverse to said first mentioned axis, said driven disc being movable laterally into engagement with one or other of the driving discs and being movable in the direction of the axis around which it rotates towards and away from the first-mentioned axis. The gear comprises a pair of spaced discs 1 and 2 fixed on the engine crankshaft 3, which is arranged transversely of the vehicle frame. Disposed intermediate said driving discs 1, 2 and in a plane perpendicular thereto is a driven disc 4, of a diameter rather less than the distance between the first-mentioned discs, said inter-





mediate or driven disc 4 being axially movable on the propeller shaft 5, disposed substantially perpendicularly to the driving shaft 3 and capable of lateral movements. The disc 4 is movable axially by operation of a hand lever 6, and laterally by operation of a pedal 7. It will be understood that when the driven shaft 5 is swung laterally to a slight extent to either side, the peripheral edge of the disc 4 will be brought into contact with one or other of the discs 1 and 2, the direction of rotation of the shaft 5 being dependent upon which of the pair of discs 1 and 2 is engaged by the disc 4, and the speed of rotation of the shaft 5 being dependent on the distance of the disc 4 from the axis of the driving shaft 3, that is, on the position of the disc 4 on the shaft 5. When the disc 4 is in contact with neither of the discs 1 and 2 there is of course, no transmission. (*Sealed.*)

124,918. The Austin Motor Company, Limited, Northfield, Birmingham, and Sir H. Austin, Northfield, Birmingham. Mounting Wheels. (2 *Figs.*) April 19, 1918.—This invention relates to means for securing a wheel upon a shaft of the type in which the shaft is provided with an eccentric surface and the wheel is provided with openings to fit both the eccentric surface and the shaft. According to this invention, the eccentric is formed integral with the shaft and is clamped to the inner surface of an eccentric recess in the wheel by a bolt which passes through the eccentric and through the wheel. An eccentric A^1 is formed integral with the shaft A. The wheel B has an opening formed therethrough, of which the portion *b*

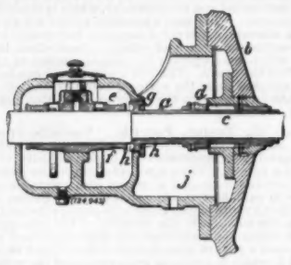


fits round the shaft and of which the portion b^1 fits around the eccentric A^1. Thus, when the drive is taking place between the shaft and wheel, the eccentric A^1 tends, under any turning action of itself in relation to the wheel, or *vice versa*, to wedge itself tightly within the portion of the opening of the wheel which fits around the eccentric, as any relative turning action between the wheel and shaft can only be about their common axis. The wheel is prevented from moving endwise of the shaft by a bolt which is passed through a slotted opening b^2 of the wheel, and a plain opening *a* through the eccentric or, of course, the opening through the eccentric may be slotted and the opening through the wheel be plain. (*Sealed.*)

PUMPS.

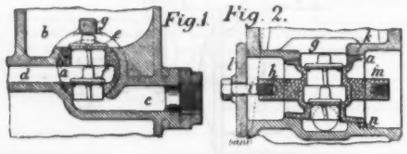
124,943. W. E. W. Millington, West Gorton, Manchester. Centrifugal Pumps. (1 *Fig.*) May 11, 1918.—This invention relates to centrifugal pumps. The sleeve *a*, which is connected with the impeller member of the pump *b* nearest to the suction

end of the pump and carried by a portion of the impeller shaft *c*, instead of terminating just outside the stuffing-box *d* at the suction end of the pump, as usual, is prolonged so as to extend to the bearing *e* for the shaft situated at the suction end of the pump, and hereinafter called the suction bearing. At this end the sleeve *a* is arranged to abut against an enlarged portion of the shaft *c* within the bearing *e*, whilst around the terminal portion of the sleeve there is provided an annular flange-like extension *g* that nearly, but not quite, closes the aperture leading to the interior of the bearing *e*. An annular groove *h*, of concave



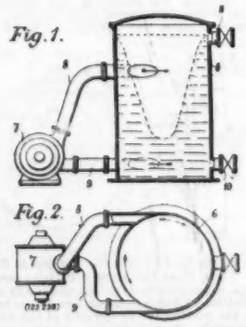
section, may be formed in each side of the extension *g*. The extension is stepped to form an annular outwardly-extending narrow flange that is outside of the bearing *e*. By this arrangement the annular flange-like extension effectually serves as an oil-thrower to prevent oil that may leak along the shaft *c* from the suction bearing bush *f* from entering the pump *b*, and also as a water-thrower to prevent any water that may escape along the shaft from the pump and through the stuffing-box *d* from entering the bearing *e*. It will also act to prevent any water that may accidentally enter and flood the casing at *j*, between the pump and the bearing *e*, from entering the latter. (*Sealed.*)

126,252. F. W. Brackett, Colchester. Pumps. (2 *Figs.*) December 18, 1918.—That part of a pump which carries the valves has been constructed in the form of a taper plug in which are the valve seatings, the plug itself being carried in a suitable cavity. By this invention the construction is improved by arranging the axis of the valves at an angle to that of the plug, instead of in the axis of the plug. *a* is the conical plug, *b* is the delivery chamber of the pump, *c* the suction pipe, *d* the connection with the plunger chamber, *e* the delivery valve, *f* the suction valve, and *g* a stop for the delivery valve. The plug may have an extension *h* having in its end face a screw-threaded bore



to receive a screw *i*, so that when a plug has been inserted in the conical socket *k* provided for it in the pump casting, it may be drawn home by turning the screw *i*, the head of which bears against a cover plate *l*. The plug may be located axially by suitable means, such as the ring pin *n*. When it is required to withdraw the plug for cleaning or repairing the valves, the screw *i* is removed, and to provide for difficulty in directly withdrawing the plug owing to its having become bound in the socket, the plug may have a second extension *m* opposite the first and also provided with a screw-threaded bore, so that the cover plate *l* and screw *i* may be applied to this end of the plug for withdrawing the latter. (*Accepted May* 14, 1919.)

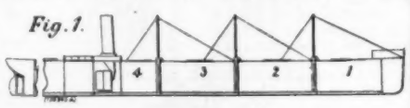
125,238. A. E. L. Scanes, Ashton-on-Mersey, and The British Westinghouse Electric and Manufacturing Company, Limited, Westminster. Pumps. (5 *Figs.*) April 23, 1918.—This invention relates to air and gas pumps of the kind utilising liquid in the form of a jet or spray as the working medium and in which the working medium is delivered to a seal tank where it is important that a large surface of liquid should be exposed. According to the invention, the liquid in the tank is caused to rotate so that a vortex is created and in this way the exposed surface of liquid assumes a paraboloidal form and is considerably increased for a tank of given horizontal area. 6 is

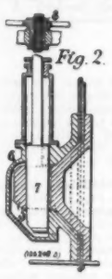


the seal tank and 7 the pump. A pipe 8 connects the discharge of the pump 7 with the seal tank 6, said pipe entering the seal tank in a tangential direction near its upper end. Another pipe 9 connects the suction of the pump 7 with the seal tank, said pipe also entering said tank in a tangential direction at a point on its circumference which is diametrically opposite that at which the pipe 8 leading from the discharge of the pump enters the tank. The seal tank is provided with an inlet 10 for make-up or cooling water, and an outlet 11 controlled by a float valve for maintaining the desired level of liquid in the tank. Owing to the velocity of the water leaving the pump which passes through the discharge pipe 8 and enters the seal tank tangentially, the water in the latter will be caused to rotate and a vortex will be created which will usually be of sufficient depth to provide the desired increase in the exposed surface of water in the tank. If a greater exposed area is required the depth of the vortex may be increased by altering the design of the pump 7 so as to increase the leaving velocity of the water discharged therefrom. (*Sealed.*)

SHIPS AND NAUTICAL APPLIANCES.

126,243. J. Nisbet, Pollokshields, Glasgow. Ship Construction. (8 *Figs.*) November 2, 1918.—This invention has for its primary objects to render practicable an increase in the number of voyages which may be made in a ship in a given time and to save unnecessary handling of cargo. The invention relates to ships of the type constituted by a plurality of separate detachably-connected sections, each complete in itself, at least one section containing propelling machinery, such sections having abutting ends disposed in vertical planes directed athwartship, and being so contrived that any desired number of sections can be assembled in selected order to form a rigid floating structure. The invention provides improved means for connecting the sections detachably together, the connecting means being all accessible from the deck, the arrangement being such that when the sections are assembled the decks thereof are substantially co-planar, that is, the decks of the sections form collectively a single continuous deck, though it is necessary

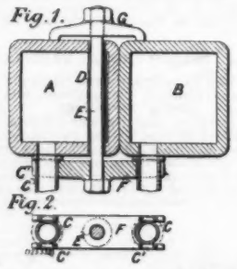




that all the sections should be of the same draught. The ship illustrated in the drawings comprises a plurality of aligned sections of which the bow section 1 and the intermediate sections 2 and 3 may be formed with cargo-receiving holds, and the stern section 4 may be equipped with propelling machinery, and may, if desired, contain the necessary accommodation for the crew, &c. The sections are assembled in end to end abutting relation, and are formed below the water-line with mating tapered spigot and socket members 5 and 6 respectively, adapted to be fitted one into the other and to be locked by means of cotters 7 having screw-threaded stems extending upwardly to near the deck level and engaged by nut-forming members 8 by rotation of which the cotters may be lowered into locking relation and raised out of locking relation. At the deck level the sections are similarly provided with tapered mating spigot and socket members respectively adapted to be locked in engagement with one another by horizontally movable cotters. (*Accepted May* 14, 1919.)

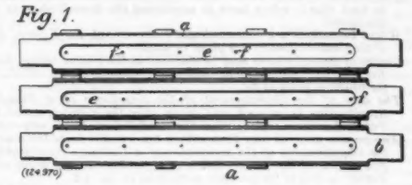
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

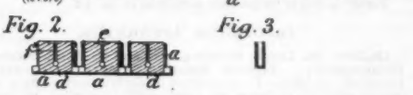
125,338. T. Sugden, London. Superheaters. (5 *Figs.*) December 7, 1918.—In a superheater in accordance with this invention the inlet and outlet headers or boxes are placed close together, preferably in contact, and one of the headers, or each header, is provided with a tube passing through it and suitably fixed therein. One such tube or pair of tubes is provided for each superheater tube, and through said tube or through each of said tubes a bolt is passed by means of which the inlet and outlet ends of a superheater tube are secured in the respective headers. A, B, are the inlet and outlet headers, C, C are the two ends of a superheater tube, one of which ends communicates with the



inlet header and the other with the outlet header. The headers have their walls in contact and therefore occupy the minimum space. Extending completely through one of the headers is a tube D, the ends of which are securely fixed to the header by expanding them. Through this tube passes a bolt E, the head of which engages a bridge-piece F, which is forked at each end and bears against collars C1, C1, formed on the ends of the superheater tube. G is a bridge-piece resting on the headers, and forming a bearing for the nut of the bolt by which the ends of the superheater tube are drawn up and firmly held against the headers. (*Sealed.*)

124,970. H. Brown, Putney, London. Furnace Bars. (5 *Figs.*) June 13, 1918.—This invention relates to improvements in furnace bars for use in furnaces consuming oil of the kind comprising a longitudinal conduit formed in the substance of the bar, the conduit being in communication with the upper surface of the bar through a series of holes through which the liquid fuel is conducted into the furnace wherein it is ignited by contact with a bed of incandescent solid fuel spread on the furnace bars. According to this invention, the improved furnace bar has a gutter formed in its upper surface substantially parallel with the conduit and the series of vertical holes provide communication between the conduit and this gutter. *a* is a furnace bar provided with supporting lugs, which rest on the furnace frame. The furnace bar has a longitudinal conduit *d* formed through it and a gutter *e* in the upper surface of the bar is in communication with the conduit *d* through holes *f*. The conduit *d* may be conveniently formed by placing a length of pipe in the mould and

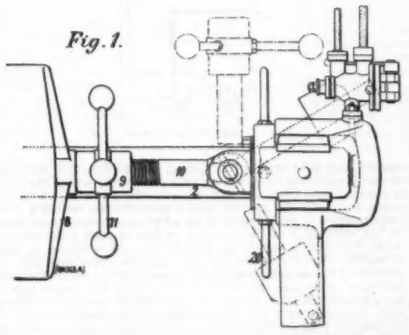


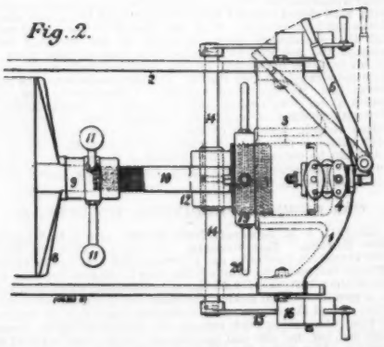


casting the bar around it, or the conduit may be formed by a sand core which is removed afterwards. Liquid fuel is admitted to the conduit *d* in each bar and flows through the holes *f* to the upper surface of the bar, where it saturates the solid fuel and is entirely consumed. If the supply is in excess, the gutter retains any surplus liquid so that no burning liquid falls from the bars into the ash pit. (*Sealed.*)

MISCELLANEOUS.

126,265. J. Miller, Derby, and George Fletcher and Co., Limited, Litchurch, Derby. Filter Presses. (3 *Figs.*) February 13, 1919.—The invention relates to apparatus for the closing of filter presses where it is desired to rapidly open or bring together the plates of a filter press and obtain a tight joint of these and the end plates of the chambers. According to the present invention, on an operating head there is mounted a pair of united ram elements, one capable of the application of a final pressure whilst the other has a larger motion and is pivoted to the former so that it may be rapidly swung into and out of position. The press is provided as usual with a headstock 1 united by tension rods 2 to the opposite end of the press. This headstock contains a hydraulic plunger moving in a cylinder 4 to which hydraulic pressure can be applied through a control valve by the operation of a lever 6. By this means final closing pressure can be applied to the follower 8. Against this follower 8 the nut portion of a screw ram is adapted to abut. This portion 9 being displaceable along the threaded portion of the ram spindle 10 by operating the hand spokes 11. The spindle 10 is hinged to lugs 12 on the plunger by means of a pivotal bolt 14 carrying





operating levers 15 having counter-weights 16. The outer end of the ram head is threaded to receive a locking nut 19 having hand spokes 20, so that after the final pressure has been applied by means of the hydraulic, the ram can be locked in this position by operation to the nut 19. In the closing of the press the filter plates will be slid along their rails and the follower 8 run up to them when the spindle 10 is dropped into the horizontal position by raising either of the balance levers 15. The flynut 9 is then rotated on the spindle 10 until its end bears on the follower, and this screwing is continued until the resistance offered to closing necessitates the employment of hydraulics. Pressure is then admitted to the ram cylinder by operating the lever 6, whereupon the locking nut 19 is operated to bear upon the ram cylinder so that ram plunger 3 is locked in position. The pressure can then be removed in the cylinder 4 by moving the valve to the exhaust position by means of the lever 6. It is, of course, desirable that as much space should be taken up by means of the ram head 9 as possible to maintain the travel on the hydraulic ram to a minimum. (*Accepted May* 14, 1919.)